OPERATOR'S MANUAL

Version 4.xx

Laser Beam Analyzer

Models LBA-300/400/500PC

Models LBA-700/708/710/712/714PC

For Windows® 2000 and Windows® XP Pro

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Chapter 1 INTRODUCTION

1.1 General Information

The Spiricon, Laser Beam Analyzer, Models LBA-300/400/500/700/708/710/712/714PC, is a low cost, PC based product for use in modern Pentium generation personal computers with high performance PCI bus architecture. It provides all the essential features needed for laser beam analysis. Some of these features are:

- High-speed high-resolution false color beam intensity profile displays in both 2D and 3D.
- Operates in Windows 2000, XP Professional, or higher operating systems.
- Numerical beam profile analysis employing advanced patented calibration algorithms.
- User selectable choices for making beam width measurement, including Second Moment methods.
- Pass/fail testing available on most measured parameters.
- Both Whole beam and Linear Gaussian fits to beam data.
- Top Hat measurements based on the beam profile or a user defined area or line.
- Signal-to-noise ratio improvement through averaging and background subtraction.
- Frame summing for cumulative effect analysis.
- Statistical Analysis of all measured parameters.
- Beam Stability analysis.
- Histogram display and results.
- Post processing capabilities.
- Both Drawn and Auto Aperturing for isolating beam data.
- Both Results and Data logging capabilities.
- Flexible printing options for hard copy generation.
- Two Divergence measurement techniques.

1.2 System Requirements

A complete LBA-PC system consists of the following equipment:

1. The Spiricon LBA-PC frame grabber card, with software.
2. A CCD style camera, or a Spiricon Pyrocam III pyroelectric camera.
3. A Pentium style or compatible PC with:
    a) High speed PCI bus, one slot available.
    b) A Pentium® or Pentium Pro® or equivalent processor based motherboard.
    c) Graphics accelerator card (support for 1024 x 768 minimum).
    d) At least 256 MB of main memory, 512 MB recommended.
    e) At least 15 MB of hard disk space available. Much more (>1 GB) if you want to log data files.

f) A high resolution color monitor.

g) Windows® 2000 or Windows® XP Professional operating system with at least 64MB of main memory.

h) A CD-ROM Drive.

i) A PC compatible mouse & keyboard.

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Notice: PC operating system, component and hardware manufactures are constantly revising their products. Therefore Spiricon, Inc. makes no guarantee that any one brand or model of Personal Computer will be compatible with any or all of the features contained in the LBA-PC application, either now or in the future.

1.3 Optional Equipment

1. Four-camera adapter, allows you to choose between 1 of 4 connected analog cameras or automatically cycle between them.
2. Digital Camera adapter, allows you to interface the output from an RS-422 or LVDS digital camera.
3. A printer with appropriate Windows compatible drivers.
4. LBS-100, BA-VIS, -NIR, or -BB Laser Beam Attenuator.

Most laser beam energy will need to be attenuated before applying it to the camera sensor. Attenuation requirements vary greatly depending upon application. Spiricon offers optional equipment for beam attenuation. Consult your Spiricon Representative or call Spiricon's Sales Department for further information.

1.4 Specifications

ENVIRONMENTAL

Operating Temperature:	0 °C to +50 °C
Storage Temperature:	-55 °C to +75 °C
Humidity:	95% non-condensing

POWER REQUIREMENTS

PCI bus loading:	+5 Vdc @ 350 mA., +3.3Vdc @ 50mA. +12 Vdc @ 140 mA.* (w/o camera) -12 Vdc @ 110 mA.
Power consumption:	4.75 watts (w/o camera)

*Total PCI load on +12 Vdc w/camera not to exceed 500 mA.

WEIGHT

Net:	Approximately 0.23 kg (0.5 lb.)
Shipping:	Approximately 1.4 kg (3 lb.)

INSTRUMENT CHARACTERISTICS

Video Input:	75 ohm Termination, ±5 volts dc max
Trigger Input:	edge sensitive (positive or negative), max input +12 Vdc, lower threshold 1.1Vdc, upper threshold 2.5 Vdc, minimum pulse width 10µs.
Trigger Output:	+5 or +12 Vdc (positive or negative), pulse width 700µs +/- 70µs.
Video Gain Adjust	.8 to 1.4 w/ LBA-7XX; .8 to ~5 w/LBA-300/400/500
Pass/Fail Output	+5 or +12 Vdc positive pulse, 250ms
Shutter Control Outputs	TTL positive logic

1.5 Safety Considerations

While the LBA-PC does not present the operator with any safety hazards, this instrument however is intended for use with laser systems. Therefore, the operator should be protected from any hazards that the laser system may present. The greatest hazards associated with laser systems are damage to the eyes and skin due to laser radiation.

1.5.1 Optical Radiation Hazards

With almost any camera used with the LBA-PC, the optical radiation at the camera sensor is low enough to be considered relatively harmless. However, usage of this instrument may require the operator to work in the optical path itself where exposure to hazards may be sufficient to warrant the use of protective equipment.

Unless the laser's optical path is enclosed, at least to the point where the beam is attenuated for use with the camera system, the operator should be protected against accidental exposure. Exposure to personnel other than the operator must also be considered. Exposure hazards include reflected radiation as well as the direct beam. When working with an unenclosed beam path, it is advisable to do so with the laser not operating, or operating at reduced power levels. Whenever there is risk of dangerous exposure, protective eye shields and clothing should be used.

1.5.2 Electrical Hazards

The LBA-PC utilizes only low voltages, derived from the PCI bus in the host PC computer, therefore it posses no risk of electrical shock.

When installing or removing the LBA-PC frame grabber card, the power to the computer should always be disconnected.

The computer should always be operated with its covers in place and in accordance with its manufacture's recommendations.

Your computer should always be operated with a properly grounded AC power cord.

If your camera has its own power supply, then follow its manufacture's operating procedures for safe operation.

Chapter 2 EQUIPMENT SETUP

2.1 Equipment Setup

This chapter describes how to get started using your LBA-PC. Follow these steps:

Step 1) Install your LBA-PC frame grabber card into your PC.

Step 2) Hook up your camera.

Step 3) Turn on the system and setup your windows environment.

Step 4) Launch the LBA-PC windows application.

Step 5) Configure the LBA-PC for your camera type.

Step 6) Begin collecting data from your camera.

Step 7) Other Configurations

Note: If you purchased your LBA-PC from Spiricon with a computer system and installation, then steps 1, 3, and 5 will have been done for you, and you can skip those steps.

2.1.1 Step 1 Installation of the Frame Grabber Board

This installation procedure applies to the following Spiricon products:

LBA-300PC

LBA-400PC (-D)

LBA-500PC (-D)

LBA-7XXPC (-D)

LBA-PC-PIII

CAUTION

Electrostatic Discharge can result in permanent damage to electronic equipment. Always ground yourself by touching the system cabinet before beginning the following procedure. We strongly recommend using an antistatic wrist strap attached to earth ground.

To install your LBA-PC frame grabber card, disconnect the AC power from your computer. Remove the cover from your computer as described in your computers technical manual. Locate your PCI bus slots. Most PC's will have either 3 or 4 PCI slots. Select an unused PCI slot and remove the rear filler bracket associated with that slot. (See figure below)

Note: If you purchased the optional 4 camera adapter, or the optional digital adapter then make sure that the slot immediately to the left (viewed from the front of your PC) of the above PCI slot is also empty, and remove its rear filler bracket also.

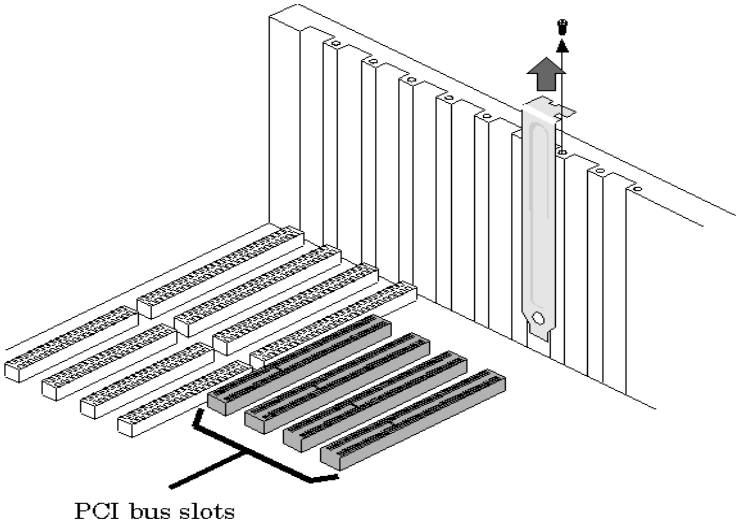


Figure 1

Carefully plug your LBA-PC frame grabber card into the PCI slot. Make sure that it is fully seated in the PCI connector. Secure the end bracket with the screw that held in the filler plate. (See figure below)

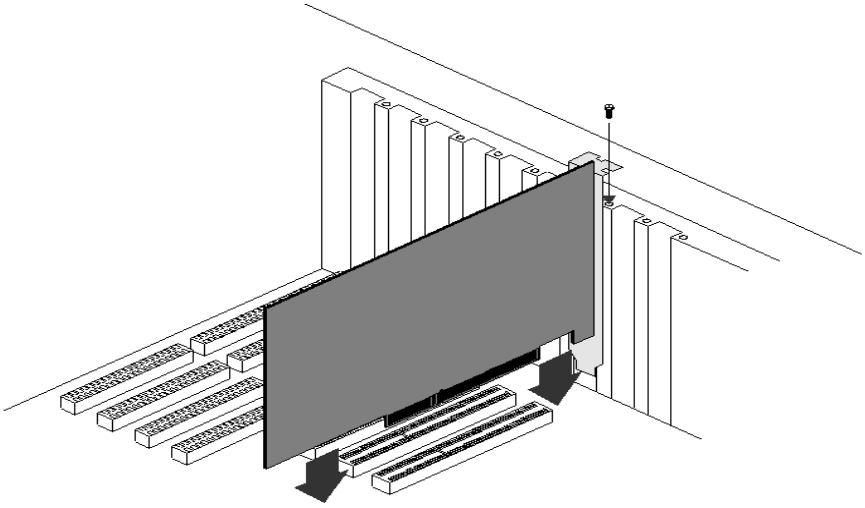
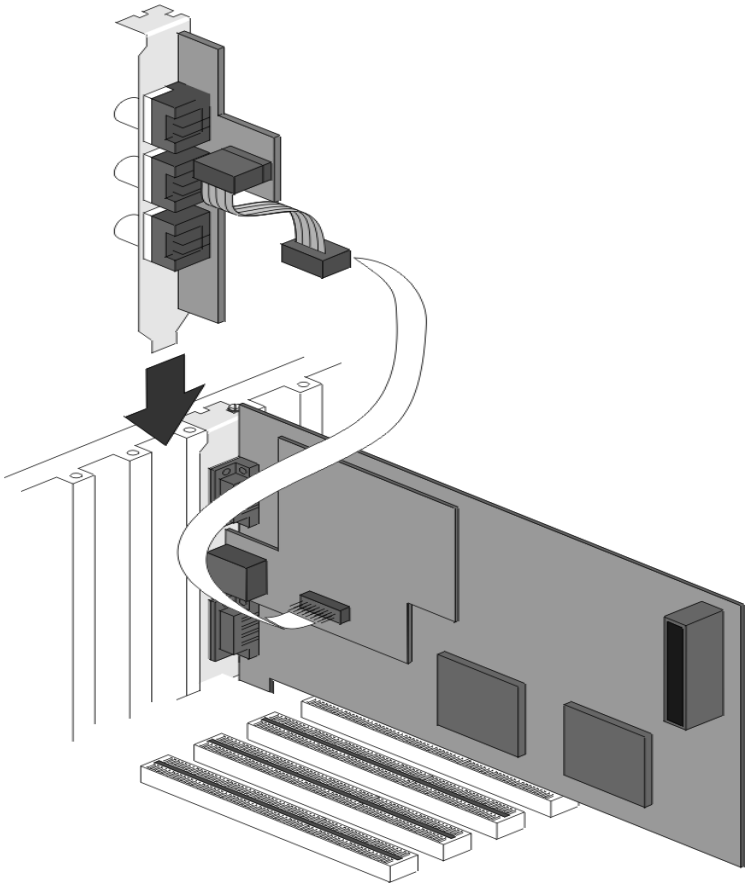


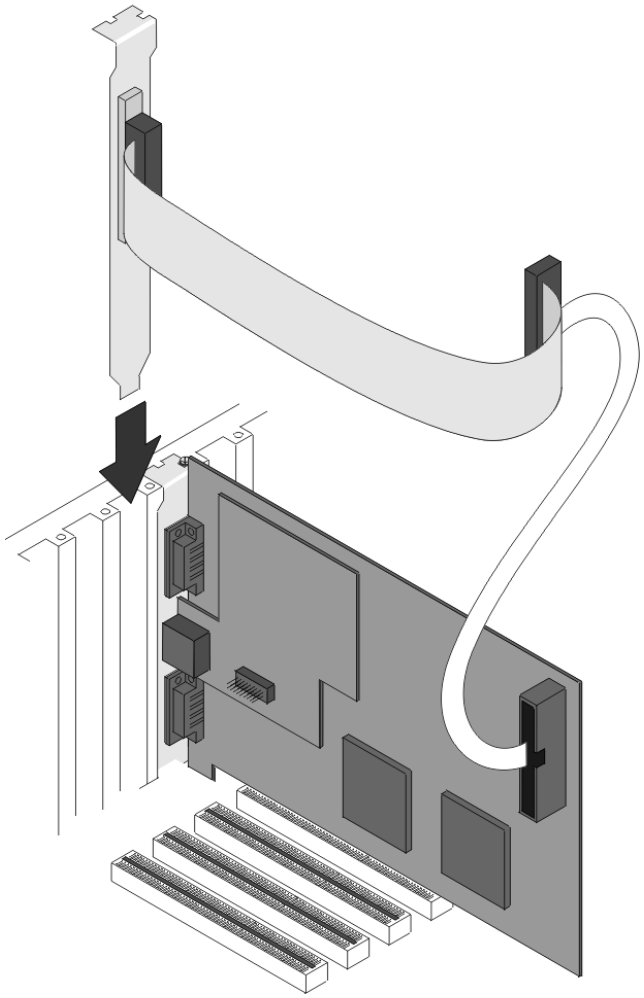
Figure 2

The optional adapters use the rear panel opening, but do not plug into any of the PC expansion slots. Rather it is provided with a short ribbon cable that plugs into the frame grabber card. (See figures below) Slide the adapter into the rear opening and plug its cable into the frame grabber card. Secure the adapter bracket to the rear panel with the screw that held in the filler plate.



Four Camera Option

Figure 3



Digital Camera Option

Figure 4

Replace the cover of your computer. Restore the AC power to your computer.

Note: The location of the connectors may vary depending upon which frame grabber model is being installed. The older LBA-400/500 series has a slightly different arrangement but the concept remains the same.

2.1.2 Step 2 Camera Connections

If you purchased a Pyrocam III to use with LBA-PC, disregard this section and refer to your Pyrocam III Installation Guide. To use LBA-PC with your Pyrocam III you must launch LBA-PC from the Pyrocam III Control Console.

2.1.2.1 Analog Cameras

Connect the video out from your camera to the BNC connector on the LBA-PC frame grabber card. This is the camera 1 input channel. If you have the 4-camera adapter option, then camera 2's input is at the top, 3 in the middle, and 4 at the bottom of the adapter bracket assembly.

If you purchased your camera from Spiricon, you may have been provided with a Camera Control Cable. This cable will usually provide power to your camera, and also control signals for your camera's electronic shutter (if it has one). Plug this cable between the appropriate 9-pin connector on the frame grabber card, and into your camera. If you have the 4-camera adapter, the additional cameras will need to be powered from an external power supply.

Your camera may also be supplied with a separate power supply. If so, connect it according to the instructions provided with the camera.

2.1.2.2 Digital Cameras

Connect the digital output from your camera to the SCSI-2 type connector on the digital camera adapter provided with the LBA-PC frame grabber card. If you purchased your camera from Spiricon, you may have been provided with a Camera Control Cable. The cable will provide the digital data connection to your camera, and may control signals for your camera's electronic shutter (if it has one).

Your camera may also be supplied with a separate power supply. Connect it according to the instructions provided with the camera. Digital cameras may require additional software to control the camera. Check with the camera manufacture and follow their instructions.

2.1.3 Step 3 LBA-PC Software Installation

After the frame grabber is physically installed in the computers PCI slot, and the PC is rebooted, windows may tell you that it has found new hardware and ask you to install its driver. If this occurs exit out of the found new hardware wizard without installing a driver and instead allow the LBA-PC installation application to load the necessary files and drivers. After the installation application has run, the hardware should be installed properly and you will not see the found new hardware wizard. If problems do occur during the installation and the drivers are not properly installed, windows will launch the new hardware wizard after the installation. If this situation should occur, tell the wizard to search automatically for the necessary drivers, finish the wizard and reboot.

Here are two ways to install LBA-PC in Windows XP; the second method will also work for Windows 2000. Choose **only one** of the following:

First Method (Windows XP):

Step 1) Start Windows.

Step 2) Close all other Windows applications.

Step 3) Place the Spiricon CD into your CD-ROM drive.

Step 4) Windows XP will open a dialog that asks: "What do you want Windows to do?"

Step 5) Click "Open folder to view files"! Windows will open a folder in the CD's root directory showing folders for each of the shipped Spiricon applications.

Step 6) Double click the "LBA-PC" folder to open it.

Step 7) Double click the file in the LBA-PC folder named "Setup.exe" to launch the install. (The windows file extensions, for this folder, must be set to viewable to see the "exe" extension.)

Step 8) Follow the instructions in the installation dialogs.

Step 9) Reboot when installation is complete.

Step 10) LBA-PC should now be installed.

Second Method (Windows 2000 or XP):

Step 11) Start Windows.

Step 12) Close all other Windows applications.

Step 13) Place the CD in the CD-ROM drive

Step 14) Click **Cancel** when Windows asks you, "What do you want to do?

Step 15) From the Taskbar, click on **Start**, and then **Run...**

Step 16) In the Open line type: R:\LBA-PC\setup.exe and press <Enter> (Where "R" is the letter of your CD-ROM drive).

Step 17) Follow the directions given in the installation dialogs.

Step 18) Reboot when installation is complete.

Step 19) LBA-PC should now be installed.

Note: After the installation is completed, The install dialogs will ask you if you want to restart windows, you must answer yes to allow windows to restart and load the drivers, otherwise LBAPC will not function properly.

Note: Be sure to look at the LBA-PC ReadMe.txt file, before starting the LBA-PC application. This will bring you up to date with any last minute information regarding the current version of the program.

The following Windows display settings may need adjustment to accommodate the LBA-PC Application. Use **Control Panel**, **Display**, and **Settings** tab to make these adjustments:

- Screen resolution should be set for a minimum display size of **1024x768**, bigger is better.
- Color Quality should be set to a minimum of 256 colors.

2.1.4 Step 4 Start LBA-PC

It's recommended that you read portions of this operator's manual to become familiar with the operation and capabilities of the LBA-PC. The operator's manual may be found on the installation disk in PDF format. The PDF may also be found on the Spiricon web site at www.spiricon.com, just following the LBA-PC product links. To start the Laser Beam Analyzer application go to windows taskbar and select:

Start, Programs>, Spiricon>, LBA-PC>, LBA-PC.

2.1.5 Step 5 Configure Camera Type

You should now have the LBA-PC application window on your monitor. The default configuration is for a basic CW laser setup. This will allow you to verify that your camera and hardware are operating correctly. If you received any error or warning messages while starting the LBA-PC application, refer to the Error Messages section in this chapter before proceeding.

Before you can begin to collect data from your camera you must select the correct camera type. To do this click **Options, Camera...,** and then click on the **Camera** drop down arrow. Select the camera type that matches (or most closely matches) your specific camera, then click on **OK**.

To save this setup configuration... Click **File**, then **Save Config...**; enter a file name for this configuration, then click **OK**. This file name has now become your new default configuration file. This default will remain, from one program startup to the next, until you save or restore a new configuration file; at which time, the last loaded or saved configuration becomes the default.

2.1.6 Step 6 Collect Data

Click the **Start!** menu item to begin collecting data from the camera. The frame display window should immediately start changing colors corresponding to the intensity of the light reaching the camera sensor, and the beam profile displays should change from a flat line in proportion to the light intensity at the cursors.

If the room light is bright enough and/or the camera is sensitive enough, the frame display window may be entirely white as the horizontal and vertical profile displays move upward and to the right, respectively. If this is the case, reduce the amount of light reaching the camera sensor by shading it with your hand. You should be able to obtain the entire range of colors shown on the color bar along the right side of the display window. If you are using a camera with a lens, you should be able to obtain a recognizable image by adjusting the lens f-stop and focus.

2.1.7 Step 7 Sample Configurations

You are probably now ready to try looking at a laser, and to go exploring the many operating options of the LBA-PC.

CAUTION

Before you expose your camera to your laser beam, make sure that the power/energy of your laser is well below the damage threshold of your camera's photo imager. You may also need to attenuate your beam to bring it into a range that will prevent your camera's imager from saturating.

To help you get started, we have created a set of configuration files that you can restore. These configuration files will adapt the LBA for a variety of basic operating modes.

However, these configuration files do not know which particular camera you are using. Therefore you must select the appropriate camera to complete your setup. To select a camera, you will have to repeat the procedure in Step 5.

The factory-supplied configuration files are write protected, so that you cannot accidentally lose or overwrite them. Each of these file names begin with a ~ (tilde), for easy identification. Some examples of these files are:

~lbapc.cfg	The original default configuration.
~cw_basc.cfg	A CW laser setup w/ basic results.
~cw_gaus.cfg	A CW laser setup w/ Gauss Fit results.
~cw_hist.cfg	A CW laser setup w/ Histogram display.
~cw_fram.cfg	A CW laser setup w/ 8 frame averaging.
~cw_elip.cfg	A CW laser setup w/ elliptical results.
~vt_toph.cfg	Video trigger mode for a pulsed laser w/ Top Hat results enabled.
~to5gaus.cfg	A Trigger Output at 5 Hz to fire a pulsed laser w/ Gauss Fit results.
~PYROCAM.cfg	For use with Pyrocam I's w/o digital camera option.
~PYRODIG.cfg	For use with Pyrocam I's w/ digital camera option.

2.2 Error Messages

The explanations of the following error messages assume that you are Windows savvy. If you find that after reading an error message's meaning, you still do not know what to do, then contact Spiricon's Service department for assistance.

You may encounter the following error messages:

LBA-PC device driver not found.

LBA-PC set to Off-Line mode

This error usually indicates that your LBA-PC frame grabber is either not installed or is not working. If the frame grabber card is not detected by Windows then the device driver will not be loaded when the system starts. This error may also indicate that the device driver was not properly installed. To determine the cause, do the following:

Windows 2000

- Click on… **Start**, **Settings**, **Control Panel**.

Or for Windows XP

- Click on… **Start, Control Panel.**

Then for Both

- Double click on the **System** icon.
- Select the **Hardware** tab.
- Click on the **Device Manager** button.

- Click on the **Sound, video and game controllers** listing.
- If the LBA-PC frame grabber was detected, and the device driver was not loaded you will see a category called **Unknown** in the edit box listing of the Device Manager. If this occurs, double click on the **Unknown** icon. You should see an entry called **PCI Card**. This indicates that the device driver was not properly installed. To correct this problem, re-install the LBA-PC software.
- If you did not see the **Unknown** icon, then Windows did not detect the LBA-PC frame grabber card. Check to see that your frame grabber card is properly installed. Sometimes PCI card slots are defective, so you might also try another slot if all else seems to be in order.

If this device driver is not found, the LBA-PC program will complete loading, but the software will be forced to the Off-Line mode. This means you can only view files and perform Post Processing of data from and/or to data files.

Device Drive vX.XX detected.

LBA-PC requires vY.YY.

LBA-PC set to Off-Line mode.

If your current device driver version does not match the current LBA-PC version you will get this message. This may occur if you have upgraded your LBA-PC application, but continue to use an old device driver. Normally this should not happen, as the installation will install a new device driver version with each upgrade. The LBA-PC application program will complete loading, but the software will be forced to the Off-Line mode. This means you can only view files and perform Post Processing of data from and/or to data files.

Unable to load LCA program file.

File Not Found.

This message will precede the following error message if the lcaXXX.exo file is not found or is not in the same path as the LBA-PC application.

LBA-PC frame grabber

detected, but cannot initialized.

LBA-PC set to Off-Line mode.

The LBA-PC frame grabber contains a programmable LCA device. If this device fails to program during application initialization, the above error message will occur. Contact the Spiricon Service Department for assistance. The LBA-PC application program will complete loading, but the software will be forced to the Off-Line mode. This means you can only view files and perform Post Processing of data from and/or to data files.

Not Enough Memory for Frame Capture.

LBA-PC set to Off-Line mode.

The device driver was unable to allocate enough memory in order to capture video frames. This may occur the first time you boot the computer after installing the Frame Grabber card. Try rebooting the computer. If the error continues to occur you will need to add memory to the computer. LBA-PC requires a minimum 256 MB of main memory, 512 MB is recommended. If the error occurs after adding memory then contact the Spiricon Service Department.

Frame Grabber not found.

LBA-PC set to Off-Line mode.

Your LBA-PC frame grabber card is either not installed, or not working. The LBA-PC application program will complete loading, but the software will be forced to the Off-Line mode. This means you can only view files and perform Post Processing of data from and/or to data files. Check to see that your Frame Grabber card is properly installed. Contact the Spiricon Service Department for further assistance.

Not a valid LBA-PC data file.

You are attempting to load a file that is not in a format that the LBA-PC can recognize. See loadable file types.

2.3 Optional Equipment

Optional equipment can include the following items:

License:	Multi-user site software license
Adapter:	4 Camera adapter
	Digital Camera adapter
Camera:	Selected camera, specify type
	Interface cable
	BNC cable
	Camera manual (if supplied by camera manufacturer)
	Camera power supply (if supplied by camera manufacturer)
Computer:	PC compatible, Pentium or equivalent
Attenuator:	Model LBS-100, BA-VIS, -NIR, or -BB beam attenuator

2.4 Connections

This topic describes the Camera Control (upper, 9 pin D-sub, female) and Trigger I/O (lower, 9 pin D-sub male) connectors on the LBA-PC rear panel. The schematic shown below describes the circuits on these connectors. See the Specifications section for the respective drive limits of these signals.

2.4.1 Camera Power

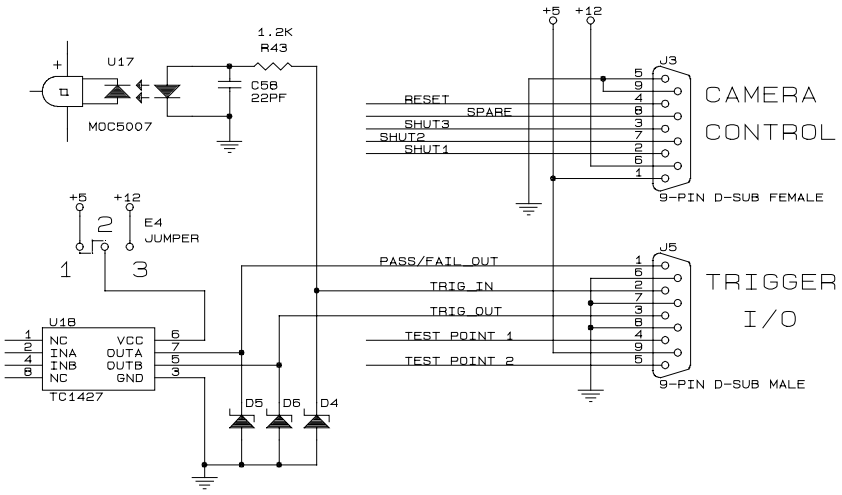
If your camera is a low power CCD style that runs on +12Vdc, then it may be powered from connector J1 (J3 on LBA-3/4/500 frame grabbers) pin 6 (+12Vdc) and pin 5 (gnd).

Caution: Do not attempt to power more than ONE camera from the LBA-PC.

2.4.2 Shutter Controls Signals

The electronic shutter control signals are provided on as SHUT1, SHUT2, and SHUT3. These are TTL level drive outputs. The Logic is positive true. The shutter settings are listed in the 8 lines of the Shutter drop down edit control found in the main menu **Options > Camera > Advanced** dialog box. The labeling of the shutter lines can be user modified to match the settings of a particular camera. The line locations however, always correspond to the following TTL output drive levels:

Shutter Line Edit control	SHUT3 (J1 pin 3) (J3 on 3/4/500)	SHUT2 (J1 pin 7) (J3 on 3/4/500)	SHUT1 (J1 pin 2) (J3 on 3/4/500)
Top line 1	0	0	0
2	0	0	1
3	0	1	0
4	0	1	1
5	1	0	0
6	1	0	1
7	1	1	0
Bottom line 8	1	1	1



Frame Grabber Pin-out

Figure 5

2.4.3 Trigger Out

Connector J2 (J5 on LBA-3/4/500 frame grabbers) pin 3 is the **Trigger Out** signal. This signal is factory set to output +5Vdc pulses. You can change this signal to +12Vdc level pulses by moving Jumper E1 (E4 on LBA-3/4/500 frame grabbers) to bridge pins 2-3.

Note: Jumper E1 (E4) controls the output signal level for both Trigger Out and Pass/Fail Out. Jumper position 1-2 yields a +5Vdc level; position 2-3 yields a +12Vdc level.

2.4.4 Pass/Fail Out

Connector J5 (J2 on LBA-7XX frame grabbers) pin 1 is the **Pass/Fail Out** signal. This signal is factory set to output +5Vdc pulses. You can change this signal to +12Vdc level pulses by moving Jumper E1(E4) to bridge pins 2-3. To enable this signal and select its mode of operation see the Pass/Fail menu topic.

Note: Jumper E1 (E4) controls the output signal level for both Trigger Out and Pass/Fail Out. Jumper position 1-2 yields a +5Vdc level; position 2-3 yields a +12Vdc level.

2.4.5 Trigger In

Connector J2 (J5 on LBA-3/4/500 frame grabbers) pin 2 is where you apply the **Trigger In** signal. This input must be only a positive voltage with respect to ground. But you can pulse it with either a high going or a low going pulse. You can program the Trigger In Polarity to respond to either a positive (rising) or negative (falling) edge of this input signal.

2.4.6 Video In

The BNC connector (not shown above) is where you input either RS-170 or CCIR formatted black and white video. The video input is terminated into 75 ohms. This is Camera input number 1. If you have purchased the 4 camera option, three additional BNC connectors are provided on a separate bracket assembly. These BNC connectors provide inputs for cameras number 2, 3 and 4 (top to bottom).

2.5 Camera Control Cables

Many cameras shipped by Spiricon will be supplied with a **Camera Control Cable**. Connect this cable between the camera and connector J1, (J3 on LBA-3/4/500 frame grabbers) the upper 9-pin D-sub female. This cable will usually provide power to the camera, as well as permit the LBA-PC to control a camera's electronic shutter, if it has one. Cameras that derive power from a source other than the LBA-PC will not usually be supplied with this cable.

If you are using the 4-camera option, any additional cameras must be powered from an external source. To provide control of the shutter of any additional cameras, a special cable must be made that connects all of the shutter inputs of the cameras in parallel. If you plan on using the automatic camera sequencing you may also need a special cable to synchronize (genloc) the cameras.

2.6 Special Setup for Pyrocam I Operation

You must use special setups if you want to successfully interface your Pyrocam I with a Model LBA-PC frame grabber system. It is strongly recommended that you first become familiar with the operating characteristics of both your Pyrocam I and LBA-PC before attempting to operate them together.

To operate your Pyrocam I with a model LBA-300PC or a LBA-400/500/708/710/712/714PC without a digital camera option, see section 2.12.1.

To operate your Pyrocam I with model LBA-500PC-D or a model LBA-7XXPC-D, with the digital camera option, see section 2.12.2.

2.6.1 Pyrocam I with Non-Digital LBA-PC's

LBA-300/400/500/708/710/712/714PC w/o digital camera option

2.6.1.1 Pyrocam I Setup Requirements:

2.6.1.1.1 Configure Video Output

The Pyrocam must be configured to output monochrome video in **CCIR** format. To do this, Dip Switch number 6 must be in the ON position. See Chapter 6 and Appendix A-6 in your Pyrocam Operator's Manual for details.

2.6.1.1.2 Configure Gain and Vertical Scale

Do not operate the Pyrocam I with the **Gain** switch set in the 10 position or with the **Vertical Scale** set in the Auto or Manual x8 positions. Use only the **1 or 3** Gain setting and **Manual x1, x2 or x4** settings. The LBA will not be able to Ultracal in the gain equals 10 or scale x8 setting positions, and the Ultracal will not remain valid if the Pyrocam is in the Auto scale mode.

Note: You will need to temporarily attach your Pyrocam to either a VGA or a monochrome monitor to observe the Vertical Scale settings.

2.6.1.1.3 Configure **MONO/DIG/VGA** switch to **MONO** position.

2.6.1.1.4 Install Video Cable

Connect the Pyrocam's Video Output BNC to the Video Input BNC on the LBA-PC.

All other operating requirements for the Pyrocam I are still applicable, and must be set up correctly. **Don't forget to periodically calibrate your Pyrocam**.

Hint: First set up your Pyrocam to operate in one of its stand-alone configurations, and then connect it to the LBA-PC only after you're sure that it is operating satisfactorily with your laser.

2.6.1.2 Setup requirements for LBA-PC with pyrocam cameras:

Two files are provided for configuring the LBA to a Pyrocam I. They are ~PYROCAM.CFG and ~PYROCAM.CAM.

2.6.1.2.1 Setting up the Pyrocam Configuration.

Go to File. . . Restore Config. . . and set the configuration to **~PYROCAM.CFG**.

2.6.1.2.2 Setting the camera type to Pyrocam

Go to Options. . . Camera dialog box and set the Camera selection to **~PYROCAM.CAM**. This may already have happened when you did the previous step.

The ~PYROCAM.CAM file is absolutely required for correct operation with your Pyrocam. The ~PYROCAM.CFG configuration is a good starting point configuration.

You will undoubtedly need to make changes to your configuration to suit your application. Do so, and then save off your new configurations into new <filename>.cfg config files. Remember the ~PYROCAM files are read only; so don't try to use those file names.

2.6.1.3 Some Restrictions apply when interfaced to a Pyrocam I

2.6.1.3.1 Frame resolution restrictions

While you are not restricted from setting your frame Resolution to 512x480x1, it is not a good idea. Keep your Resolution setting set to 128x120x4. Remember the Pyrocam creates a 124x124 sized image, so setting higher resolutions only wastes memory and slows down operations.

2.6.1.3.2 Zooming restrictions

In keeping with the above, do not use Hardware zooming. Only use Soft zooming, i.e. double-right-mouse click in the Zoom window.

2.6.1.3.3 Restricted pixel regions

Because of the image size difference between the LBA and the Pyrocam I, as noted above, the LBA will clip off 4 rows from the Pyrocam; two on top, and two on the bottom. Also the LBA will have 4 dark columns; two on the left edge, and two along the right.

2.6.1.3.4 Scale and resolution restrictions

Note also that the Pixel Scale setting is set to 25mm, not 100mm, which is the actual pixel scale of the Pyrocam I. This is because the image output by the Pyrocam in CCIR mode is 4 times over scanned in both the x and y directions. Thus the LBA's 1x resolution comes out to be 1/4th the 4x resolution. Keep this in mind if you plan to change the scaling because of placing the beam altering optics in the beam path.

2.6.1.3.5 Camera settings restrictions

Under no circumstances, make any changes to the Advanced. . . Camera settings for the Pyrocam I.

2.6.1.4 Image synchronization considerations

The Pyrocam I's CCIR video output is always producing video images at the rate of 25 frames per second. Furthermore, it only changes output image after acquiring and processing a new image. Thus the rate of a new output beam image is a function of many variables, including Pulse or Chop rates, image processing time, and results computational times.

If you are using a Pulsed laser with your Pyrocam I, the Pyrocam will continue to output the image of the last laser pulse that it receives. As a result, your LBA will continue to collect data frames that are multiples of the last pulse received by the Pyrocam. To relieve this, you may want to set up a Trigger input to the LBA. This will cause, at the most, only one image to be acquired for each Laser Pulse. This can be a tricky situation since the Pyrocam does take a little time to process each image, and that time will vary somewhat from image to image. Also, if your laser is triggered faster than the Pyrocam can acquire and update its CCIR display, it will skip pulses. Thus the LBA can still end up acquiring multiples of some of the processed pulses. You can also try the solution described below for the Chopped-operating mode.

The exact same type of problem occurs in Chopped mode. The chop frequencies must be either 24Hz or 48Hz. Thus, the CCIR image can never be updating as fast as the chopper is triggering the Pyrocam. Consequently, the CCIR output is always creating multiple frames of the same beam profile. In this case, you may want to set the LBA's Capture interval to a value that will eliminate or reduce multiple frame captures.

2.6.2 Pyrocam I with Digital LBA-PC's

LBA-500/7XXPC-D w/ Digital Camera Option

2.6.2.1 Pyrocam I setup requirements:

To use this interface method, your LBA-500/7XXPC must be equipped with the digital camera option (-D), and your Pyrocam I must be of a later design that has digital output capability. Early versions of the Pyrocam were not equipped with digital outputs. If your Pyrocam I does not have a 50 pin connector on its rear cover it can not be interfaced as a digital camera. However, you can still interface it by using the analog method described in the LBA-300PC interface topic. Alternately, you can contact Spiricon's service department and arrange to have your Pyrocam I upgraded with digital camera output capability.

NOTICE: When interfacing with a Pyrocam I, DO NOT USE THE ULTRACAL! Feature of the LBA-PC. Rather, it is ESSENTIAL that you periodically re-calibrate the Pyrocam I. Calibrating the Pyrocam I is the only calibration that should be used with this type of interface.

2.6.2.1.1 Set video switch

The Pyrocam must be set to output digital video. This is accomplished by setting the **MONO/DIG/VGA** switch to the **LBA** position. See Chapter 6 in your Pyrocam Operator's Manual.

2.6.2.1.2 Connect cable

Connect the Pyrocam's digital output to the digital input connector of the LBA-500PC. A special interface cable is required to make this connection. If you ordered your Pyrocam I, LBA-PC and LBA-Digital Option together as a system, then a cable was supplied.

2.6.2.1.3 Pyrocam settings

With the Pyrocam set to the **DIG** mode, the **Vertical Scale** setting has no effect on the output. However, the **Gain** switch is still operating and can be set to any position. All other operating requirements for the Pyrocam I are still applicable, and must be set up correctly. **Don't forget to periodically Calibrate your Pyrocam**.

Hint: First set up your Pyrocam to operate in one of its stand-alone configurations, and then connect it to the LBA-PC only after you're sure that it is operating satisfactorily with your laser.

2.6.2.2 LBA-500/7XXPC-D Setup requirements:

Two files are provided for configuring the LBA-PC digital interface to a Pyrocam I. They are ~PYRODIG.CFG and ~PYRODIG.CAM.

2.6.2.2.1 Set the Pyrocam configuration

Go to file. . . Restore Config. . . and set the configuration to **~PYRODIG.CFG**.

2.6.2.2.2 Set the camera options

Go to Options. . . Camera dialog box and set the Camera selection to ~**PYRODIG.CAM**. This may already have happened when you did the previous step.

The ~PYRODIG.CAM file is absolutely required for correct operation with your Pyrocam. The ~PYRODIG.CFG configuration is a good starting point configuration.

You will undoubtedly need to make changes to your configuration to suit your application. Do so, and then save off your new configurations into new <filename>.cfg config file. Remember the ~PYRODIG files are read only, so don't try to use those file names.

Under no circumstances make any changes to the Advanced… Camera settings for the Pyrocam I.

2.6.2.3 Image Synchronization Considerations

The Pyrocam I's Digital Output only produces an image each time new data is available. It will not continuously output the same frame repeatedly. Thus, the rate of new output beam images is a function of the Pulse or Chopping rate and image processing time. For this reason, you should operate the LBA-500PC in Video Trigger mode only.

If you are using a Pulsed laser with your Pyrocam I, the Pyrocam will attempt to output a new image with each laser pulse, however, depending upon the pulse rate, it may not be able to keep up.

The exact same type of problem occurs in Chopped mode. The chop frequencies must be either 24Hz or 48Hz. The Pyrocam may be able to keep up at 24Hz, but will lose some frames at 48Hz.

Chapter 3 MENUS AND DIALOG BOXES

3.1 File. . . Drop Down Menu Selections

3.1.1 File | Load. . .

A saved data file can be loaded into the frame buffer for display and results processing. Four types of data file formats are supported and are delineated by their file extension labels. The results obtained from these file types are not all of equal merit, however. The origin and meaning of these file types are as follows:

.lb3/4/5/7 Files

Is the native file extension denoting a data file created by the **LBA-PC**. The number indicates that the data was created by either the LBA-300 (8-bit frame grabber), -400 (10 bit frame grabber), –500 (12 bit frame grabber), or with a new –7XX (multi-format frame grabber). If the saved file was generated using **Ultracal** processing then the results obtained when loading and viewing this file type are of high quality.

.lba Files

Is the native file extension denoting a data file created by the **LBA-100A**. If the saved file was generated using **Autocal** processing then the results obtained when loading and viewing this file type are of high quality. All of these files produce images that are 120 x 120 pixels.

.lbb Files

Is the native file extension denoting a data file created by the **LBA-100A**. All file types of this designation are created without the benefit of any calibration, and thus can not be relied upon for accurate results. All of these files produce images that are 256 x 240 pixels.

.lbc Files

Is the native file extension denoting a data file created by the **LBA-100A**. All file types of this designation are created without the benefit of any calibration, and thus can not be relied upon for accurate results. All of these files produce images that are 512 x 480 pixels.

NOTICE:

File Compatibility with New versions of LBA-PC Software.

We will try very hard to make all future releases of the LBA-PC application backwards compatible with all prior .lb3/4/5 file formats. However, we cannot guarantee that new versions will produce .lb3/4/5 files that will be backward compatible with older versions.

Beginning with release v2.50, any of the three .lb3, .lb4, and .lb5 file types can be read by any of the LBA-300/400/500PC model types. However, the new .lb4 and .lb5 file types cannot be read by software released prior to v2.5.

Beginning with release v4.00, any of the three .lb3, .lb4, and .lb5 file types can be read by any of the LBA-7XXPC model types. However, the new .lb7 file types cannot be read by software released prior to v4.00.

Data files can contain one or more frames of data. Each frame of data is called a **Record**. Embedded in each **Record** is all the information necessary to accurately reproduce the original frame. Pixel scale, Camera type, Zoom and Pan location, energy and Ultracal values etc. are saved within each **Record**.

Note: If you load an LBA-100A record that used a different camera setup than the one you currently have configured, then one or more of the following can occur:

- If the Camera type file is available, it will be loaded and replace the current settings. See Camera type selection.
- If the Camera type file is available, but the pixel scale or resolution settings do not agree with the current settings, it will be loaded and the Pixel Scale and Resolution settings changed to match the data file values.
- If the Camera type file is not available, the camera type will be set to NONE, and the Pixel Scale and resolution will be changed to that required of the Data File.

3.1.1.1 Load Frame Dialog Box

Enter the drive:\paths\and <filename>.lbx of the File that you want to load. Press Browse... if your not sure of the file's name or location, and wish to search for it.

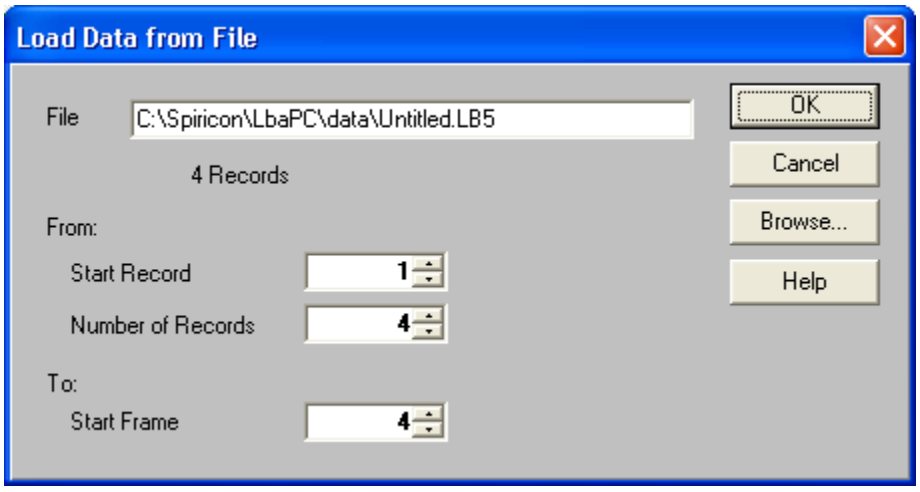


Figure 6

If the file that you are loading contains multiple records, enter the starting number of the record that you want to begin loading from, in the edit box labeled **Start Record**.

Enter the **Number of Records** that you want to Load. You can enter a value of 0, or 1 to the number of records in the file. A value of 0 means all the records in the file.

Records can only be loaded sequentially from the **Start Record** position. If you specify a greater number of records than you have frame buffer space available, the loading process will fill the buffer and then wrap around leaving the last records transferred in the frame buffer. See setting the frame buffer size in 3.2.3.4.

In Start Frame, enter the location in the frame buffer where you wish to begin depositing the file records. Multiple frames will load from that location upward, skipping any locations that are Write Protected.

3.1.1.2 Special Frame Numbers

The following Frame numbers have special meanings, however they can be saved and loaded in the usual manner.

- Frame 0 is the Reference Frame
- Frame -1 is the Gain Correction frame, not a true image frame, but rather an array of gain correction factors.

3.1.1.3 Drag and Drop Data Frame Loading

You can perform a Load Frame operation by dragging and dropping one or more data frame files from **Windows Explorer**, or by double clicking the data file name. If you have not already started the LBA application, using the double click method will start it automatically.

These Drag and Drop shortcuts will work on all Data Frame formats. However, the current camera configuration must match the camera configuration of the data file that you are attempting to load. If you Drag and Drop a data file that contains multiple records, all the frame records will be loaded into the frame buffer up to the maximum size of the buffer. For example: If you Drag and Drop a file with 20 records, and your frame buffer is sized at 10 frames, then only the first 10 records in the data file will be loaded.

To perform a Drag and Drop, open **Windows Explorer**. Highlight the data file(s) that you want to load. With the Mouse cursor over the file name, press and hold down the left mouse button while dragging the highlighted files to the LBA-PC application.

3.1.2 File | Save As...

You can save or append data frames in the frame buffer to disk files. All data files saved by the LBA-PC will have a **.lb3/4/5/7** file name extension.

Data files can contain one or more frames of data. Each frame of data is called a **Record**. Embedded in each **Record** is all the information necessary to accurately reproduce the original frame. Pixel scale, Camera type, Zoom and Pan location, energy and Ultracal values etc. are saved within each **Record**.

3.1.2.1 Save As … Dialog Box

Enter the drive:\paths\<filename> of the **File** that you want to save. Press **Browse...** if you want to append or overwrite an existing file, and you are not sure of the file's name or location and wish to search for it.

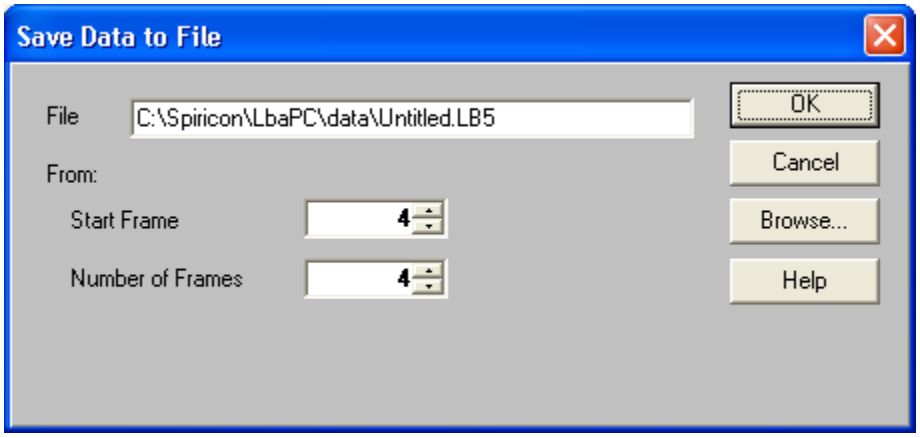


Figure 7

Enter the **Start Frame** buffer location from which you want to begin saving or appending frame data files.

If you wish to save multiple records, enter the **Number of Frames** that you want to save or append. Multiple data frames can only be saved sequentially from the **Start Frame** location. You can specify 0, or 1 to the number of frames in the frame buffer. A value of 0 means all of the frames in the frame buffer.

3.1.3 Export Image... to a disk file

Exporting is an operation that is designed to take data and images out of the LBAPC and use them in other applications. Exports are a bad choice for data storage because there is no way to reload exported data into the LBA-PC! Bitmaps for example, are one of the exporting options. Bitmaps (.bmp) are simply pictures of the beam image and do not represent a viable data source for numerical analysis. If the user desires to do some external computations on exported data, ASCII formats have been provided and are the only viable method for doing so.

Bitmap images will appear just as the current beam display window image appears. The two **ASCII** file types are **.cma** and **.spa**. The **.cma** type uses **Comma** delimited entries. The **.spa** type uses **Space** delimited entries. Spreadsheet programs like Excel and Lotus 123 typically use comma delimited data entries. Math programs like Mathcad typically use space-delimited formats. Consult your application program to determine which style to use.

You can also save **1D beam display** images that are defined by the location of the Horizontal and Vertical Cursors. **Cursor files** are designated with a **.cur** file type. Cursor files are **ASCII** files that use **Comma** delimited entries. The Cursor image is organized Horizontal data first, left to right, followed by a carriage return, and then the Vertical data, top to bottom.

You can also save a **Column and Row summed beam image** that is defined by the total of all pixel values summed in both the Horizontal and the Vertical direction. **Column/Row summed files** are designated with a **.sum** file type. Summed files are **ASCII** files that use **Comma** delimited

entries. The Summed image is organized Horizontal data first, left to right, followed by a carriage return, and then the Vertical data, top to bottom.

*Note: Exported image files cannot be read back into the LBA-PC's frame buffer. Use **Save As...** and **Load...** for retrievable data files.*

3.1.3.1 Export Image… dialog box

Enter the drive:\paths\and <filename> of the **Export File Name** that you want to create. Press **Browse...** if you want to overwrite an existing file, and you are not sure of the file's name or location and wish to search for it.

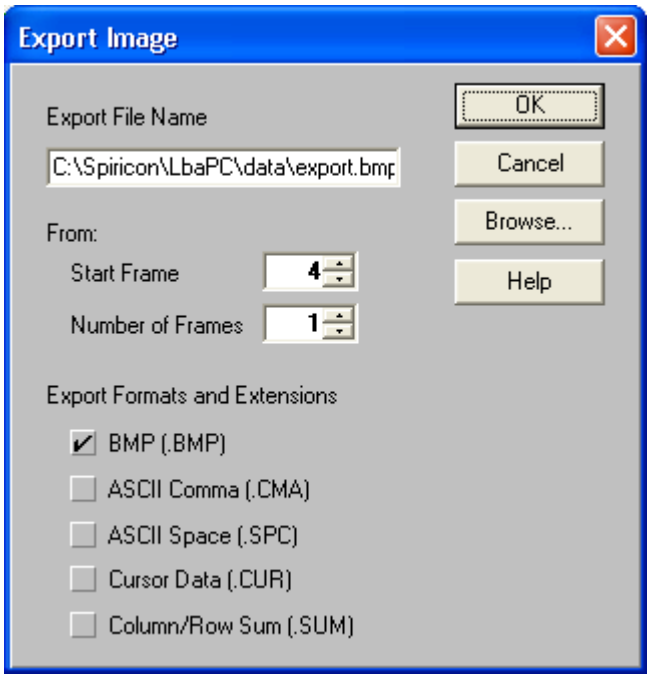


Figure 8

Enter the **Start Frame** buffer location from which you want to begin exporting image data files.

If you wish to save multiple images, enter the **Number of Frames** that you want to export. Multiple export images can only be saved sequentially from the **Start Frame** location. You can specify 0, or 1 to the number of frames in the frame buffer. 0 means all the frames in the frame buffer.

When Exporting **multiple images**, each image will be placed into a separate file. The file name will automatically have a six-digit number appended to the entered file name. This number will designate each file in the sequence starting with 000000 and counting up. Thus a given multiple export will create a series of files that will appear as follows:

<filename>000000.cma;<filename>000001.cma;...<filename>NNNNNN.cma

Click on the image file **Export Format** (or Formats) that you want to generate.

3.1.4 Save Config... to a file

The current setup configuration of the LBA-PC can be saved to a disk file. All configuration files have the **.cfg** file extension. Whichever configuration was the last to be saved (or restored), will become the default configuration the next time the LBA-PC application is run. The configuration file contains **all** setup parameters of the LBA-PC menus.

The configuration file does not preserve and thus will not restore Data frames, Reference frames, Gain Correction frames, or Ultracal processing information. The above types of frames must be saved and restored separately. Ultracal processing data must be generated immediately prior to the acquisition of new data frames, as it relates to present camera calibration requirements.

3.1.5 Restore Config... from a file

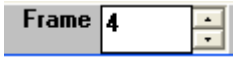
Past setup configurations of the LBA-PC can be restored from previously saved **.cfg** disk files. All configuration files have the **.cfg** file extension. Whichever configuration was the last to be restored (or saved), will become the default configuration the next time the LBA-PC application is run. The configuration file contains **all** setup parameters of the LBA-PC menus.

The configuration file does not preserve, and thus will not restore, Data frames, Reference frames, Gain Correction frames, or Ultracal processing information. The above types of frames must be saved and restored separately. Ultracal processing data must be generated immediately prior to the acquisition of new data frames, as it relates to present camera calibration requirements.

Notice: Restoring a configuration does not force a read of a <camera>.cam camera type file. Rather it restores the Camera dialog box settings, just as they where when the configuration file was created.

3.1.6 Set Reference, copy the current to the reference frame

Set Reference

Click on this button, to copy the **Current Frame** or the **Gauss** fit results of the current frame to the **Reference** frame buffer. The **Reference** frame is frame number 0 (zero), in the frame buffer. You can view the reference frame by single or double clicking into the **Frame** indicator/edit control 

(located in the lower status bar) and entering a **0** (zero). You cannot bring the reference frame into view by cycling the **Frame** spin controls.

The **Set Reference Source** item in the **Capture** dialog box determines the style of the Save Reference data.

3.1.7 Generate Gain

Clicking this item will cause the LBA-PC to execute an automatic Gain Correction calculation cycle. The results of this operation will store a gain correction table that will be used to preprocess all data frames newly acquired from the Frame Grabber card.

The status of the Gain Correction condition is visible in the Gain correction Enunciator shown here and at the bottom of the LBA-PC's main display screen.

If the color of the Gain Correction Enunciator is:

GRAY Gain Correction processing is turned OFF.

GREEN The Gain Correction calculation was successful and is OPERATING.

RED Gain Correction processing has been disabled because something caused the usage of it to become invalid.

3.1.7.1 How to generate gain

Before clicking on the **Generate Gain...** item you must:

- Allow the camera to warm up to a normal operating temperature.
- Align your laser beam with the camera and set the correct Zoom, Pan Camera type and resolution, etc. settings.
- Block all light from the detector and perform an **Ultracal**!.
- Uniformly illuminate the camera detector to an intensity level that is about 60% to 90% of saturation.

Now click **File, Generate Gain.**

- After a few seconds.. observe that the Gain Correction enunciator turns Green.
- Remove the uniform illumination and re-apply your laser beam to the camera.

*Note: It is highly recommended that you perform a **Save Config...** and a **Save Gain As...** operation in conjunction with each **Generate Gain...** operation. This will insure that you can restore the settings to the configuration that will allow the Gain Correction to operate correctly.*

3.1.7.2 What is Gain Correction?

The gain correction algorithm will compute a mean pixel intensity value, and then supply a correction factor for each pixel that will correct it to the computed mean. If your camera has dead or seriously defective elements you should not attempt to use or operate with Gain Correction.

3.1.7.3 What Disables Gain Correction?

Gain Correction will become DISABLED if certain data collection conditions, that were in effect when the Generate Gain operation was executed, are no longer in effect. In all cases, these conditions are the result of an operators change to the spatial acquisition settings. The DISABLED condition will occur if you make changes to:

- The Hardware Zoom.
- The Hardware Pan location.
- The Camera Type or Resolution setting.
- The Camera Electronic Shutter setting.
- The Video Gain and/or Black Level settings.

*Warning: Gain Correction should be used with only **one camera at a time**. It will not correctly operate in conjunction with the for camera option when automatic camera cycling is enabled.*

3.1.8 File | Load Gain...

You can restore a previously saved **.gai** Gain Correction file from disk. The Gain Correction enunciator will turn GREEN if the loaded file will operate under the current setup conditions. If it cannot operate under the current setup conditions, it will show RED.

*Note: It is highly recommended that you perform a **Restore Config...** on a **.cfg** configuration file that was saved at the same time that the **.gai** Gain Correction file was created. This will insure that you can restore the settings to the configuration that will allow the Gain Correction to operate correctly.*

3.1.9 File | Save Gain As...

You can save the current Gain Correction table to a file. All gain correction files will have a **.gai** file name extension. You will not be able to save the Gain Correction table unless you have previously created it using **Generate Gain**.

*Note: It is highly recommended that you perform a **Save Config...** and a **Save Gain As...** operation in conjunction with each **Generate Gain...** operation. This will insure that you can restore the settings to the configuration that will allow the Gain Correction to operate correctly.*

3.1.10 Gain Off/On

Click on this button to turn Gain Correction processing OFF or ON. This item will only operate if a Gain Correction table is present. For a Gain Correction table to be present it must have been created by **Generate Gain**, or by being loaded from a disk file via **Load Gain**.

3.1.11 File | Logging...

The LBA-PC will allow you to log into disk files, in any combination, any of the following:

- Frame Data
- Numerical Results
- Frame Export Images

Data Logging files will have a .lb3/4/5/7 file extension name. The frames in a Data Logging file can be read back into the Frame buffer by using the File and Load... menu selections.

Results Logging files will have a .rlg file extension name. Results Logging files are for exporting numerical results to other applications, such as Spreadsheets or Math programs. Text editors can also view them. Results files are saved in ACSII.

Export Logging files can be of four different file types, .bmp, .cma, .spa, .cur. Export Logging files are write only. They are created for logging images for use in other applications like spreadsheets or math programs such as MathCAD. Unlike the .lbx Data file types, Export Logging creates multiple files rather than one large concatenated file with multiple records. The assigned file name will automatically have a six-digit number appended to the entered file name. This number will designate each file in the sequence starting with 000000 and counting up. Thus, an Export Logging operation will create a series of files that will appear as follows:

<filename>000000.cma; <filename>000001.cma; … <filename>NNNNNN.cma

3.1.11.1 Beginning and Terminating Logging

You **begin** a logging file when you go to the Logging... dialog box and:

- Check a type of logging
- Provide a file name
- Click on **OK**
- Click on **Start!**

You **terminate** a logging file when you Stop! collecting frames and:

- Return to the Logging dialog box
- Uncheck the logging type
- Click on **OK**

Warning: Once you have begun a logging cycle, each file entry is sequentially recorded until you terminate the log via the method described above. If you Stop! and then re-Start! the logging process, the new entries will continue to be added as before; HOWEVER, the Frame counter or the Timer (whichever might apply) will be reset to 0 (zero) each time you press Start!. In Export Logging, the file frame numbering does not reset, but rather continues to increment from the last number assigned. This number is only reset each time logging is enabled.

Example: If you were setup to log 1000 frames, and you hit Stop! at frame 521, and then hit Start! a second time; when the logging process stops automatically, the log file will contain entries for 1521 frames.

3.1.11.2 Data, Results & Export Logging, dialog box

If you want to log frames of data, check the **Data Logging** box and enter the

drive:\paths\<filename> of where you want the data records to be logged.

If you want to log computed results, check the **Results Logging** box and enter the drive:\paths\<filename> of where you want the results records to be logged.

If you want to log frames of image data, check the **Export Logging** box and enter the drive:\paths\<filename> of where you want the image data to be logged.

Press the respective **Browse...** if you want to append or overwrite an existing file, and your not sure of the file's name or location and wish to search for it.

If you choose **Results Logging**, select the **Format** that you want the data to be logged in. Both formats will produce an ASCII text log with comma-delimited entries. The **Spreadsheet** format will precede the log with a single list of column headings. The **Math Program** format will precede each log entry with a binary number that indicates which results are enabled.

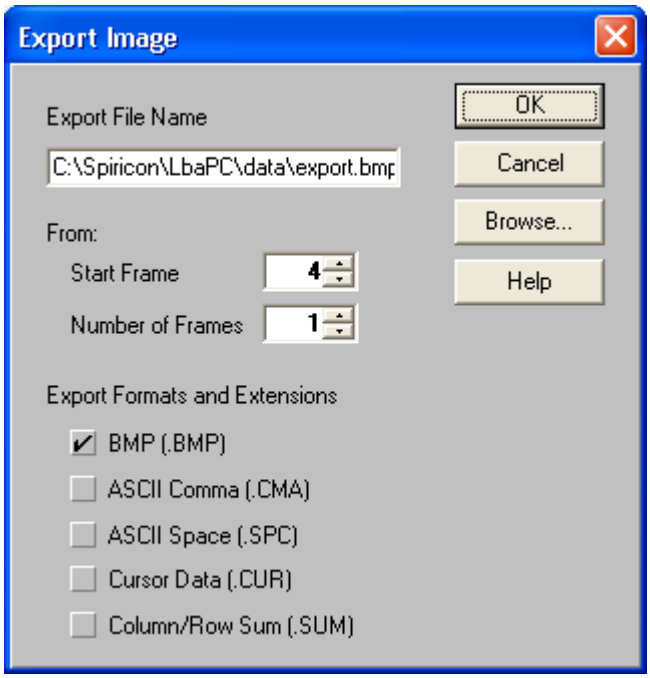


Figure 9

If you choose **Export Logging**, select the **Format** that you want the data to be logged in. The **.BMP** format will produce bitmapped image files. The **.SPA** format will produce an ASCII text image file with space-delimited entries. The **.CMA** format will produce an ASCII text image file with comma-delimited entries. The **.CUR** format will log only the Cursor image in and ASCII format with comma delimited entries. The **.SUM** format will log only Column/Row summed data in an ASCII format with comma-delimited entries. See the Export Image section for more information regarding these file types.

3.1.11.3 Logging Method

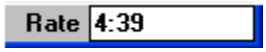
You can choose between three different methods to log data or results.

- **Continuous**: Logging will commence when you click **Start!** on the menu tool bar and will terminate when you click **Stop!**, or run out of available disk space.
- **Frames**: You can limit the logging process to a specified **Number of Frames**. Enter the number of frames you want to log. Logging will commence when you click **Start!** on the menu tool bar.
- **Time**: You can limit the logging process to a specified amount of time. At the **HHH:MM:SS** entry item, enter the amount of time that you want logging to run. Double-click inside the entry item and type in the time value in the format shown. Logging will commence when you click **Start!** on the menu tool bar.

If you use the **Frames** or **Time** method, the logging operation will automatically **Stop!** when the Frame count or the Timer values have run out. To protect the log file from inadvertent additions, use the above described terminate method to secure your log file.

When Logging is **Frames** or **Time** limited, the **Rate** display will indicate the number of frames to go,

or the time remaining .



3.1.11.4 Pass/Fail Filter

You can filter out certain frames of data from being appended into your log file by using the Pass/Fail Filter, in conjunction with choices made in one or more of the **Pass/Fail** menu items. For example, if you only wanted to log frames that exceeded a certain minimum amount of *Energy*, choose **Passed Frames Only**. Then in the **Quantitative Pass/Fail** dialog box, under **Total Energy**, check **Minimum** and enter the minimum value of the energy that you require to pass this filter in the space provided.

Refer to the section on Pass/Fail Menu Operation for more details on how to use the Pass/Fail options.

How fast will logging operate?

The rate at which frames can be processed and logged to disk depends upon such variables as: how many and what types of calculations are being performed, what type of logging is enabled, how fast is your disk/computer system, etc. We recommend that you run tests to find out how fast your system can log various forms of data and results, and use those as your system benchmarks.

3.1.12 Implications of Combining Logging, Statistics, Post Processing and Block Capture

Before reading this topic you should be familiar with the operating modes available for:

- Results Logging - Section 3.1.11
- Statistics Results - Section 3.2.6.10
- Post Processing - Section 3.2.4.1
- Block Capture - Section 3.2.4.1

Logging, Statistics, Post Processing and Block Capture each have built in control features that can limit their respective run lengths. The limiting factors can be either manual intervention by an operator, a programmed number of frames, or a programmed time limit.

Note: Post Processing and Block Capture do not allow for a programmed time limit. In addition, Post Processing and Block Capture are mutually exclusive.

Because of the flexibility in setting control options, it is possible to set conflicting control parameters. Therefore, it is essential that these various conflicts be resolved by a prioritized control scheme.

Of course, a perceptive operator can avoid all of these possible conflicts. Nevertheless, owing to the complexity of these features, setup errors are almost a certainty.

Hint: To avoid a conflict in the above features, never set more than one of the above to use either a Time limit or a Frame count, at any one time.

3.1.12.1 Combinations using Logging, Statistics and Block Mode

The following control priorities are in effect when any of the above features are used in combination. The first feature in the list that is enabled has control.

1. **Block Mode**: Controlled by a set number of frames.
2. **Data or Results Logging**: Controlled by a set time limit.
3. **Data or Results Logging**: Controlled by a set number of frames.
4. **Statistics Results**: Controlled by a set time limit.
5. **Statistics Results**: Controlled by a set number of frames.

If **Results Logging** and **Statistics** are both in play, and if one of the **Logging** features is in control: The Statistics results are recorded into the Results Log file when the Logging operation is terminated. See Beginning and Terminating Logging. Section 3.1.11.1.

If **Results Logging** and **Statistics** are both in play, and if one of the **Statistics** features is in control: The Statistics results are recorded into the Results Log file whenever the Statistics collection cycle is completed.

3.1.12.2 Combinations using Logging, Statistics and Post Processing.

The following control priorities are in effect when any of the above features are used in combination. The first feature in the list that is enabled has control.

1. **Post Processing**: Controlled by a set number of records/frames unless the number is set to zero.

Note: By setting this number to zero you can allow the Logging and Statistics operation to operate on multiple records from multiple files.

2. **Data or Results Logging**: Controlled by a set number of frames.
3. **Statistics Results**: Controlled by a set number of frames.

No timed operations are recognized when Post Processing is enabled.

If **Results Logging** and **Statistics** are both in play, and if the **Logging** feature is in control: The Statistics results are recorded into the Results Log file when the Logging operation is Terminated. See Beginning and Terminating Logging. Section 3.1.11.1.

If **Results Logging** and **Statistics** are both in play, and if the **Statistics** feature is in control: The Statistics results are recorded into the Results Log file when the Statistics collection cycle is completed.

3.1.13 File | Print...

The **Print** dialog box is where you tell the LBA-PC what information you want it to print. You can only get here via the **File**, and **Print...** menu item. If you just click on the print button, located on the Capture toolbar, then printing will begin immediately, based upon the last configuration that you set in the **Print** dialog box.

Check the **Beam Image** box if you want to print the contents of the Beam Display Window. The printed image will contain everything that you see, limited only by the resolution and color capabilities of your printer and Windows printer driver.

Check the **Results** box if you want to print the results information. The printed results will consist of all enabled numerical results including Statistics and Histogram.

Note: In both of the above, if the related child Window (Beam, Results, Histogram) is minimized, then the associated item will not be printed. In other words, what you see is what you get.

If both **Beam Image** and **Results** are checked, they will be printed Beam first then Results. If the **Separate Pages** box is checked, then the Beam and Results will be printed on separate pages.

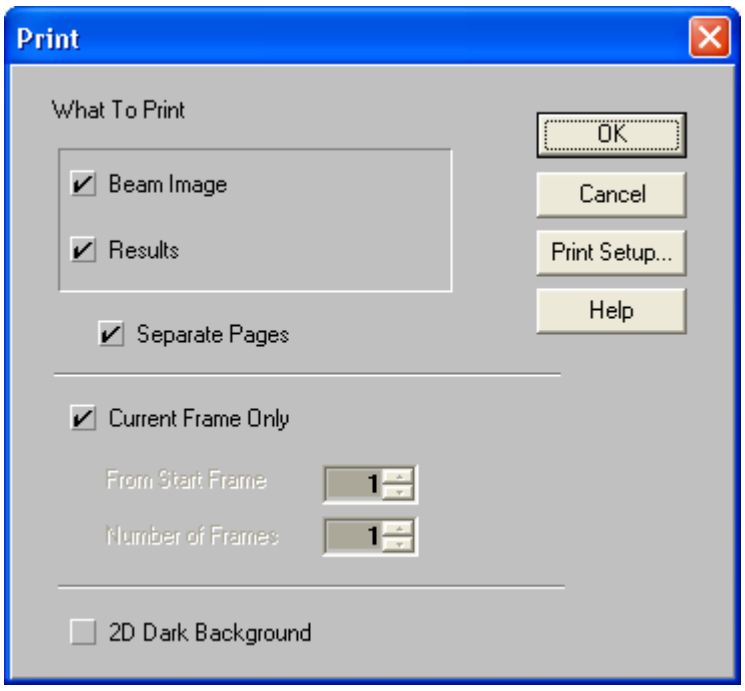


Figure 10

If you check the **Current Frame Only** box, then *only* the currently displayed frame and/or its results will be printed. If this box is not checked, you can direct the LBA to print multiple frames by

specifying the **From Start Frame** location, and the **Number of Frames** to print. The **Number of Frames** can be 0, or 1 to the number of frames in the frame buffer. 0 means all the frames in the frame buffer. When printing multiple frames you will observe that the LBA will cycle through the designated frame locations. It will compute the required results for each frame and then print whatever is required. At the end of this process, the last frame printed and its results will be displayed.

If **Statistics** results are enabled, they will not update during the printing operation and thus will show the same values on each frame's printout.

*Hint: Keep the **Current Frame Only** box checked unless you really need to print multiple frames.*

When printing 2D beam images, in either 128 or 16 colors, the dark violet background color will be converted to a shade of light gray. This may not always be appropriate, as you may want to preserve the dark background, for example, if you are printing transparencies. To restore the normal background appearance, click on the **2D Dark Background** check box.

3.1.14 File | Print Setup...

This is the standard Windows style **Print Setup** dialog box. From here you can select which printer to use, and make some basic print format choices. You may also be able to go from here to your specific printer's **Options** dialog box and make other choices that pertain to your printer.

3.1.15 File | Exit

Click on Exit to leave the LBA-PC application and return to the Windows Program Manager. This will end your current Beam Analysis session.

Before exiting:

- Do you want to save the current setup to a configuration file?
- Have you correctly terminated any logging files?
- Do you need to save any frame data files?
- Do you need to save any important Reference frame data?
- Do you need to save a Gain Correction table?

3.1.16 File | Save FROG as...

You can save a frame of data to an ASCII disk file that can later be used as input data to Femtosoft's FROG or X-FROG software application. All FROG ASCII files saved by the LBA-PC will have a .frg file name extension.

Only the currently displayed frame can be saved to a FROG file. A FROG file can contain only 1 frame of data.

3.1.16.1 Save FROG as…Dialog Box

Enter the drive:\paths\and <filename> of the FROG File that you want to save. Press **Browse...** if you want to overwrite an existing file, and you are not sure of the file's name or location and wish to search for it.

The FROG file format can be of two types, without a header or with a header. We recommend that you use the header format to add to the unique identity of each FROG file.

Click on the **Use Header Information** check box to enable Header information to be automatically placed at the start of the FROG data file. Default is for this box to be checked. When it is not checked all the following items in this dialog box are disabled.

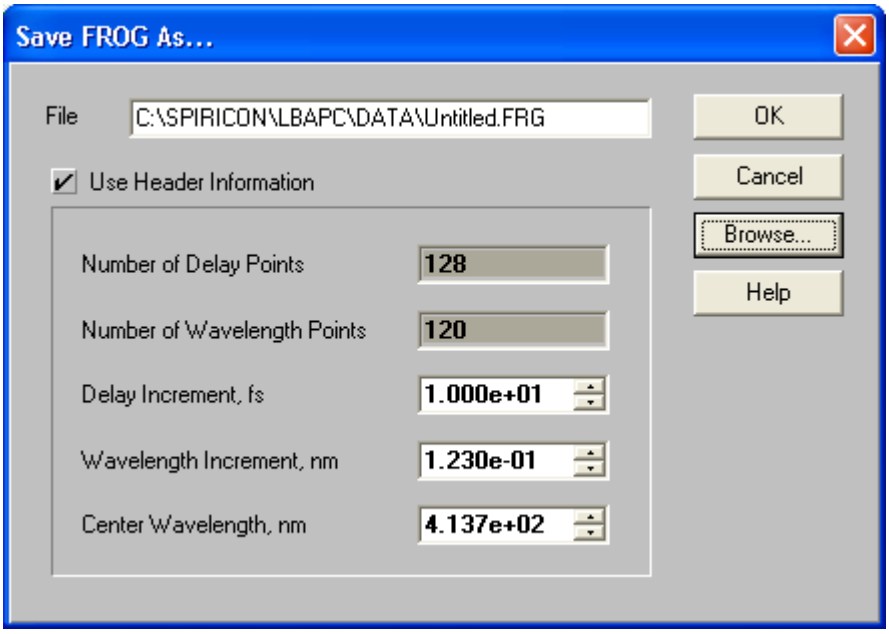


Figure 11

The item labeled **Number of Delay Points** automatically sets to the number of horizontal pixels in the current beam.

The item labeled **Number of Wavelength Points** automatically sets to the number of vertical pixels in the current beam.

The edit control item labeled **Delay Increment, fs** must be set by the operator to the delay per pixel scale value. Units are femto-seconds. Control range is +/-10,000.000.

The edit control item labeled **Wavelength Increment, nm** must be set by the operator to the wavelength per pixel scale value. Units are nanometers. Control range is +/- 10,000.000.

The edit control item labeled **Center Wavelength, nm** must be set by the operator to the value of the wavelength at the center of the vertical column of pixels. Units are nanometers. Control range is .001 to 10,000.

3.1.16.2 FROG Data Orientation

The FROG software has the ability to flip axial assignments and directions. There is, however, a legacy defined orientation that we use as a basis for defining our axial representations. This is also the FROG default condition.

Looking into the front of the camera, the upper left corner defines a starting point for the vertical Spectrum axis and then the horizontal Delay axis. (See figure below).

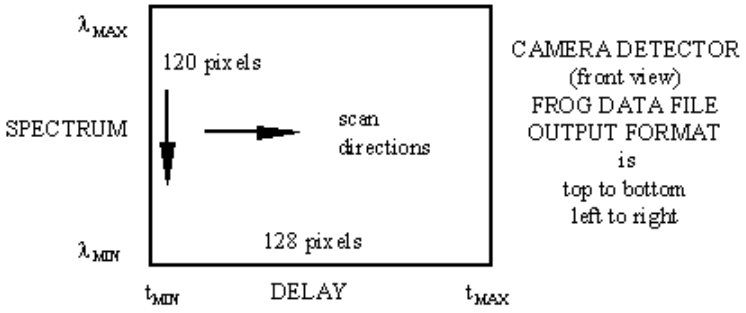


Figure 12

In the vertical/Spectrum direction, the top represents a maximum wavelength (lowest frequency), moving down to a minimum wavelength (highest frequency).

In the horizontal/Delay direction, the left represents a minimum time delay moving right to a maximum time delay.

If you align your axes differently than shown, you can make the necessary adjustments by altering the **Delay** and **Wavelength** settings in the dialog box and in the **Exp. Data** tab section of the **FROG Algorithm Calibration** dialog box.

Note: The LBA-PC always builds the .frg data file in the format depicted above, listing the columns top to bottom then stepping from left to right.

Reference the FROG on-line Help for details on the FROG data file format.

3.1.16.3 FROG Data Collection Tips

Most of the LBA-PC data collection features are not required when collecting FROG data. Thus, the Results child window can be minimized, which will speed up data collection. The following list contains some Do's and Don'ts for reducing errors when collecting FROG data:

- **DO** use Ultracal! just prior to starting a data collection cycle.
- **DON'T** enable Lens in the Camera dialog box.
- **DO** save your configuration when the camera is aligned with your spectrometer.
- **DON'T** drive the camera into saturation.

- **DO** consider Frame Summing if the FROG pulses are too weak to yield sufficient amplitude.
- **DON'T** use the pan and zoom features or you will mess up the scaling parameters. You can minimize the Pan/Zoom child window to reduce temptation.
- **DO** consider Frame Averaging if the FROG pulses are noisy.
- **DON'T** enable Convolution.
- **DO** use the Video Trigger method if pulse amplitude is high enough.
- **DON'T** use apertures.

3.2 Options... Drop Down Menu Selections

3.2.1 Hide/Show; Capture, Display, Aperture Toolbar

The above three toolbars can be selectively displayed or hidden based upon operator preference. Check the action that applies.

The **Capture** and **Display** toolbars can be user defined to match the operators needs.

The **Aperture** toolbar is predefined and can not be altered by the operator.

3.2.2 Aperture... display and define apertures

The LBA-PC can display three types of apertures in four different shapes. The three types of apertures are:

- **Drawn:** You can manually draw a **WHITE** aperture for the purpose of isolating beam analysis to the pixel data contained within the aperture. This feature allows you to eliminate the effects of noise or stray energy in regions outside of the beam under test.
- **Displayed:** The **BLACK** displayed aperture is not really an aperture. Rather it is an overlaid graphical representation of the computed shape and size of the beam width/diameter results. This BLACK aperture provides a way for the user to visually see the beam width, and observe how it changes.
- **Auto:** This feature automates the task of drawing an optimally sized and placed aperture around the beam profile being measured. This aperture is displayed in **YELLOW**. It performs the same function as the Drawn aperture, except that it will continuously resize itself to changing beam conditions.

All three of the above apertures can be enabled and visible at the same time on a 2D display. In the 3D display mode **no** apertures are ever displayed, however the **Drawn** and **Auto** apertures can be operating as described above. If you've enabled the apertures while in the 3D display mode, be sure to check their setup in the 2D display mode.

The **Drawn** and **Auto** apertures, when operating at the same time, function in the following manner:

- First, the **Drawn** aperture isolates the energy for analysis.
- Second, an **Auto** aperture is computed and drawn around the beam energy.
- Third, the reported beam widths/diameter is computed based upon the energy contained exclusively within the **Auto** aperture.

3.2.2.1 Aperture Shapes

Drawn and **Displayed** apertures can be rendered in four shapes.

- Circle
- Square
- Ellipse
- Rectangle

Auto apertures are always rendered as an Ellipse.

3.2.2.2 How to create a Drawn Aperture

You can create a **Drawn** aperture by using the Aperture dialog box, the Aperture toolbar, or by dragging and dropping the aperture in the 2D display window.

Note: Before you can use the drag and drop method you must first select a Drawn aperture shape using either of the first two methods.

The **Aperture dialog box**, and the **Aperture toolbar** offer the same choices for creating a Drawn aperture. The entries that define a Drawn aperture are listed vertically within the recessed panel of the dialog box. These same entries are arranged horizontally on the aperture toolbar. You can make the same changes from either location. The following discussion will reference the dialog box, but applies equally to the toolbar.

Choose an aperture **Shape**. Enter the aperture's **Center** location in **X** and **Y** coordinate values.

Note: You can modify any edit text control item by double-clicking inside the item and typing the new value.

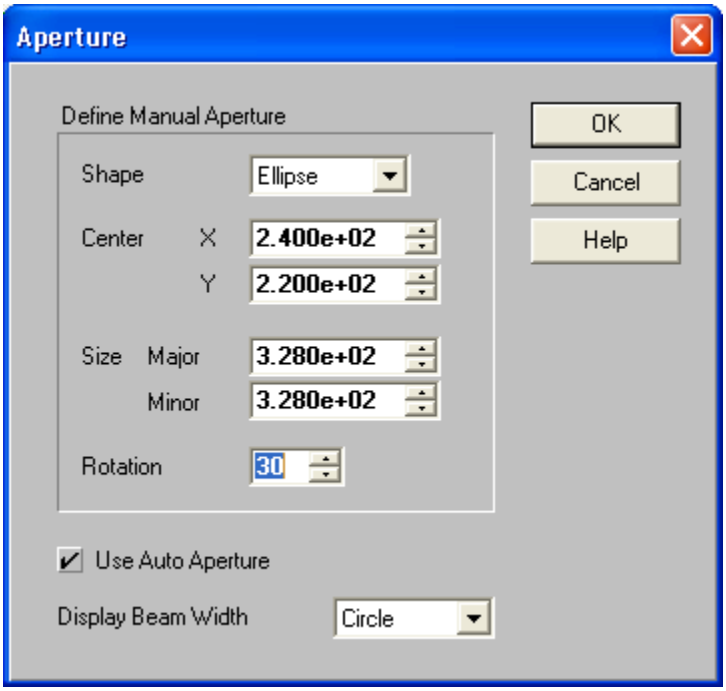


Figure 13

- If the aperture is an **ellipse or rectangle**, enter the **Size** of the **Major** and **Minor** axes, followed by the **Rotation** angle of the Major axis in degrees.
- If the aperture is a **circle or square**, enter the **Diameter** (not shown above).

3.2.2.3 Drag and Drop Apertures

Once you have enabled a **Drawn** aperture from either the dialog box or toolbar, you can move, resize, and (in the case of an ellipse or rectangle) rotate it.

Move the arrow cursor over the display window and press and hold down the RIGHT mouse button. This will reveal the Drag, Drop and Rotate hot spots of the Drawn aperture.

Move the arrow cursor onto one of these hot spots, release the RIGHT mouse button and press and hold down the LEFT button. The cursor will change shape indicating the selected Drag and Drop function.

Now drag the mouse to see what happens to the aperture.

The four cursor styles perform the following operations:

Moves the aperture center.

Size the aperture right or left.

Size the aperture up or down.

Rotate an elliptical or rectangular aperture.

3.2.2.4 Using Auto Apertures

To enable the **Auto** aperture feature, click on the **Use Auto Aperture** box, or click on the Auto aperture button on the Aperture toolbar.

*Note: **Auto** apertures are drawn in **YELLOW**, are always ellipses, and are only visible on 2D displays. Auto apertures will be drawn on the X and Y axes of the beam if **Elliptical is OFF**, and on the Major and Minor axes of the beam if **Elliptical is ON**.*

You should always enable **Auto** apertures whenever performing second moment **D 4-Sigma** beam width measurements.

If your beam is small, relative to the acquisition window size, you should either use a **Drawn** aperture of 2x to 2.5x the beam width, or enable **Auto** aperturing to perform this task for you. **Auto** apertures will help improve beam measurement accuracy on almost any beam shape. **Auto** apertures may not improve accuracy, or operate well, if you have a lot of stray energy adjacent to the beam profile. In this case you should rely more on a well placed **Drawn** aperture, and avoid using the **D 4-sigma** beam width method.

3.2.2.5 Display Beam Width

If you want to see your beam widths/diameter graphically overlaid on the laser beam profile, choose the shape that most correctly matches your beam.

These choices are also available from the Aperture toolbar.

The displayed beam widths will appear as a BLACK aperture in a 2D beam display window. This aperture will not appear in 3D displays.

If your beam is an off axis ellipse or rectangle be sure to turn on **Elliptical** in the **Options... Computations...** dialog box. Otherwise all drawn beam widths will be computed and displayed on the X and Y axes.

3.2.3 Camera... selection and display resolution

The Camera dialog box is where you make the following selections:

- Identify current Camera type, or Create a New Camera type.
- Select the maximum image Resolution.
- Select how large the Frame Buffer will be.
- Select the Sync Source of your camera.
- Modify the Pixel Scale if needed.
- Apply Gamma correction if needed.
- Choose the Lens mode if your camera is so equipped.

3.2.3.1 Camera type selection.

Find your camera...

Camera types are saved in <camera>.cam files. Camera files contain setup information that will allow the LBA-PC to operate correctly with the specified camera. Included with the LBA-PC installation is a group of common <~camera>.cam type files. These files include most cameras that will be used with the LBA, and apply to camera operation without a lens, i.e. the camera's detector alone determines the pixel scale. These files are write protected so that you will not be able to accidentally delete or modify them. To permit easy identification, these write protected camera files will have a ~ (tilde) symbol included as part of their file name.

Click on the Camera type drop down arrow.

Select your camera type from the list.

If your camera type does not appear:

- Check that your camera path is pointing to the location where the .cam files are stored. Click on CAM Path... and select the path as required.
- Create a new Camera type.
- Contact Spiricon's Service Dept. for assistance.

3.2.3.2 Creating a new Camera Type

Do you really need a new camera type?

One common reason that you may need to create a new camera type would be if you use a camera with a lens that changes the effective pixel scale. In this case it is best to begin by selecting the supplied common camera type that matches your camera. For example, you might be using a Pulnix TM-745 style camera fitted with a special lens. Start out by selecting the **~Pulnix_TM-745.cam** type and clicking OK. This will cause the LBA to load in all the basic setup information needed for this camera.

Now return to the **Camera** dialog box and do the following:

- Double-click inside the **Pixel Scale**, **V** edit text control.

- Type in the new camera pixel scale value.
- Verify that the **Pixel Units** are set correctly, change as required.
- Double-click inside the **Camera** type edit text control.
- Type in a new 8 character file name. The **.cam** extension will automatically be added if you fail to include it.
- Click on **Save CAM...**
- If the file path and name specified is correct, click **OK.**
- You will return to the Camera dialog box. Click **OK.**

Your new camera is now active, and saved as a **<camera>.cam** type file.

Note: You may now also want to perform a Save Config... operation, so that when you restart the LBA-PC application, this new camera setup will automatically be restored. Otherwise, you must return to the **Camera** *dialog box and select this camera type each time you restart the LBA application.*

Notice: A Restore Config... operation will occur each time the LBA application is started. Camera type selections will only occur when you the operator consciously, unconsciously, but not sub-consciously..., make a choice. Which ever of the above actions occurs last, is the one that is controlling the Camera dialog box settings.

3.2.3.3 Resolution and Frame Size

The Resolution value specifies how finely the incoming video image is to be digitized. This will also determine the maximum frame size when viewing an un-zoomed image. The Resolution value is not related to the resolution performance of your camera.

The smaller the Resolution value, the higher the resolution of the display, and the greater the number of pixels that will be contained in the un-zoomed image. Consequently, each frame will take more memory in the frame buffer and on disk, and it will take longer to process the frames, thus the system will run slower.

The Resolution value will control how much memory is allocated for each frame. This figure does not change dynamically as you zoom in. In other words, if you set the resolution to 1x, a frame size of 512x480 is reserved in memory for each frame that is digitized. If you then hardware zoom in twice, to a frame size of 128x120, you will be wasting 93.75% of each reserved frame buffer locations space, since a 120x128 image is only 1/15th the size of a 512x480 image.

Thus, you should never specify a resolution that is more than what you need to do the job at hand. Otherwise, you will waste system resources and reduce your overall throughput.

Analog camera image sizes are fixed to resolution values per the following table:

Resolution value	**Max Frame Size... WxH (un-zoomed)**	**≅ Number of frames in 8 Mb of memory**
Full 1x	Hor. Size X Vert. Size	n.a
1x	512 X 480	16
2x	256 X 240	64
4x	128 X 120	256
8x	64 X 60	512
16x	32 X 30	2048

The Full 1x resolution will create an image size equal to the Horizontal Size and Vertical Size shown in the Camera…, Advanced dialog box. This size is the maximum obtainable from the type of analog camera selected.

Digital cameras do not follow the above resolution table. For digital cameras both the Full 1x and 1x resolutions produce image sizes equal to the Horizontal Size and Vertical Size shown in the Camera…, Advanced dialog box. The 2x, 4x,..etc. sizes will reduce the resolution by approximately ½ in both the horizontal and vertical directions, rounding to the nearest even values.

Figure 14

3.2.3.4 Frame Buffer Size

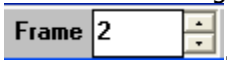
The Frame Buffer Size refers to the total amount of memory that is allocated in your system for the temporary storage of digitized frames of video. There are two ways to set the size of the frame buffer. You can enter the amount of memory that you want to allocate to this buffer, or you can specify the number of frames that you want the buffer to contain. We recommend that you set the number of **Frames**, rather than the **Buffer Size**. This will allocate just the optimum amount of memory for the set **Resolution** value.

3.2.3.4.1 What is the Frame Buffer?

The Frame Buffer is an allocated block of memory in your PC. It will receive and temporarily retain frames of digitized video data. The frames in the Frame Buffer are numbered from 1 to N, where N is the maximum number of frames that the allocated amount of memory can hold. You must always have at least 1 allocated frame in the frame buffer.

The Frame Buffer is loaded in a sequential round robin fashion. Frames of data can be placed into the frame buffer by:

- Digitizing the video input signal.
- Transferring data from a digital camera.
- Loading in data from disk files.
- Post processing data already in the frame buffer.
- Post processing data coming from a disk file.

In the far lower right hand corner of the Main Screen display is a Frame edit and spin control 

. The number showing in the edit control is the number of the frame currently displayed. You can edit this number by double-clicking and typing in a new value, or you can use the spin control to increment or decrement to the frame desired.

We recommend that you set the frame buffer to hold as many frames as your Windows environment has real memory available. This will prevent the LBA-PC application from trying

to use virtual memory as Frame Buffer space. A little virtual memory assigned to the frame buffer is not too bad. A lot can make you wonder what kind of alien being has just taken over your hard drive.

Also, Windows will allocate real memory first, and when it's gone, begin allocating virtual memory. For this reason it is a good idea to run the LBA-PC application with no other application(s) operating in the background. This will free up as much real memory as possible for Frame Buffer use.

3.2.3.5 Am I using Virtual Memory yet?

How do I know when my Frame Buffer is running over from real into virtual memory? Easy..., your hard disk drive light will begin to flicker when the real frame buffer capacity is filled, and the virtual file swapping begins. To avoid this, try reducing the Frame Buffer size until it stops.

Note: Be sure to perform this test with Logging disabled.

3.2.3.6 Sync Source

Many applications will use standard analog output cameras. For analog cameras the **Sync Source** must be set to **Genlock**. The LBA-400/500/7XXPC models can be purchased with an option that will allow support for both Analog and Digital cameras. Note: the model LBA-300PC cannot support digital cameras.

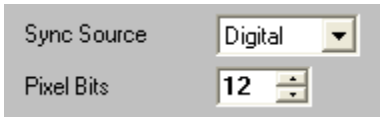


Figure 15

If you have purchased the digital camera option with either an LBA-400/500/7XXPC, and are connecting a digital camera, set the **Sync Source** to **Digital**.

In **Digital** mode, the **Pixel Bits** entry must be set to the number of data bits that are being input to the LBA. If you purchased an LBA-400PC-D, you can choose 8, 9, or 10 bits per pixel. If you purchased an LBA-500PC-D, you can choose either 8, 9, 10, 11 or 12 bits per pixel. If you purchased an LBA-7XXPC-D, you can choose either 8,10,12,14 or 15 bits per pixel.

If your camera's digital output is in a signed twos compliment data format, select a minus Pixel Bits value. For example, the Pyrocam I outputs 12 bit signed 2's compliment digital data. Thus, the Pixel Bits setting is –12.

If your digital camera has more bits of resolution than can be accommodated by the LBA-PC, you must connect only the upper most significant bits. Any left over data bits will not be processed by the LBA-PC.

Note: There may be some jumper traces on the frame grabber card that will need to be cut if you are using a digital camera that is outputting fewer bits than the default configuration. The default is 10 bits for the LBA-400PC-D and 12 bits for the LBA-500PC-D. The LBA-7XXPC-D models use the software to set the number of bits rather than jumpers.

3.2.3.7 Pixel Scale, Pixel Units

For analog cameras that use the **Genlock** sync source, only the **V**..ertical **Pixel Scale** is set. The pixel scale value is derived from your camera's detector specifications, or is user programmable to match the characteristics of your optical system. For the camera imager based scale setting, the value to enter is the minimum line pitch of the camera's detector.

For **Interline** and **Full Frame** transfer type cameras, the line pitch is the vertical element pitch of the CCD detector. For pseudo-interlaced **Frame** transfer type cameras the line pitch is ½ the vertical element pitch. Check your camera specifications to accurately determine the correct value to enter here. This value is not always as obvious as it may seem.

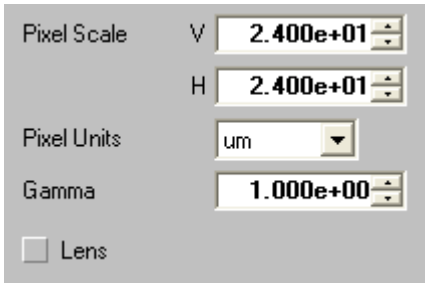


Figure 16

The **H**..orizontal **Pixel Scale** setting is only used with **Digital** output style cameras. For digital cameras the data is clocked by the camera's element rate clock, and its focal plane array determines the horizontal pixel scale. In this case you must enter a value that is the horizontal pixel pitch of the camera.

Choose the **Pixel Units** that applies to your pixel scale value. Camera detector pixel pitch is specified in micro-meters (µm), and all provided **.cam** files are specified in **µm**.

3.2.3.8 Gamma Correction

If your camera employs a solid state CCD or MOS style detector, then your camera's detector responds linearly to monochromatic light. For linearly responding cameras the **Gamma** setting should be set to 1.

If you are using a vidicon tube style camera, or a phosphor coated imager, then your output response is less likely to be linear, and you may need to enter a **Gamma** correction number that matches the gamma of your camera. Note: Correction is performed on the entered gamma value so enter the gamma value of the camera response, not the inverse gamma correction factor.

Notice: Many CCD cameras have selectable gamma settings. Be sure to set your CCD camera to a gamma of 1.

3.2.3.9 Lens

Click on this box if your camera is fitted with a lens. When enabled the 2D image orientation is adjusted to depict the image as if the observer is standing and viewing the scene from behind the camera.

When disabled, the 2D image is oriented as if the observer is standing in front of the camera looking at the surface of the detector.

3.2.3.10 Special Camera Settings

The Special Camera Settings dialog box contains the electronic parameters that define a camera to the frame grabber board. All of these values are saved inside of a cameras **.cam** type file. We are not going to tell you much about these settings because we don't want you accidentally changing something important and running amuck. If you want to experiment with a new camera type, one that is not in our camera selection list, then we recommend that you call our Service Department and ask for assistance. We'll be happy to lend a hand.

*Notice: If you change a setting here, and then do a Save Config..., the change **will** be saved with the configuration file, and be restored when the configuration file is restored.*

3.2.4 Capture... define acquisition method and processing

The **Capture** dialog box is divided into four areas. These four areas each control different aspects of the image capturing process. Each area will be discussed separately.

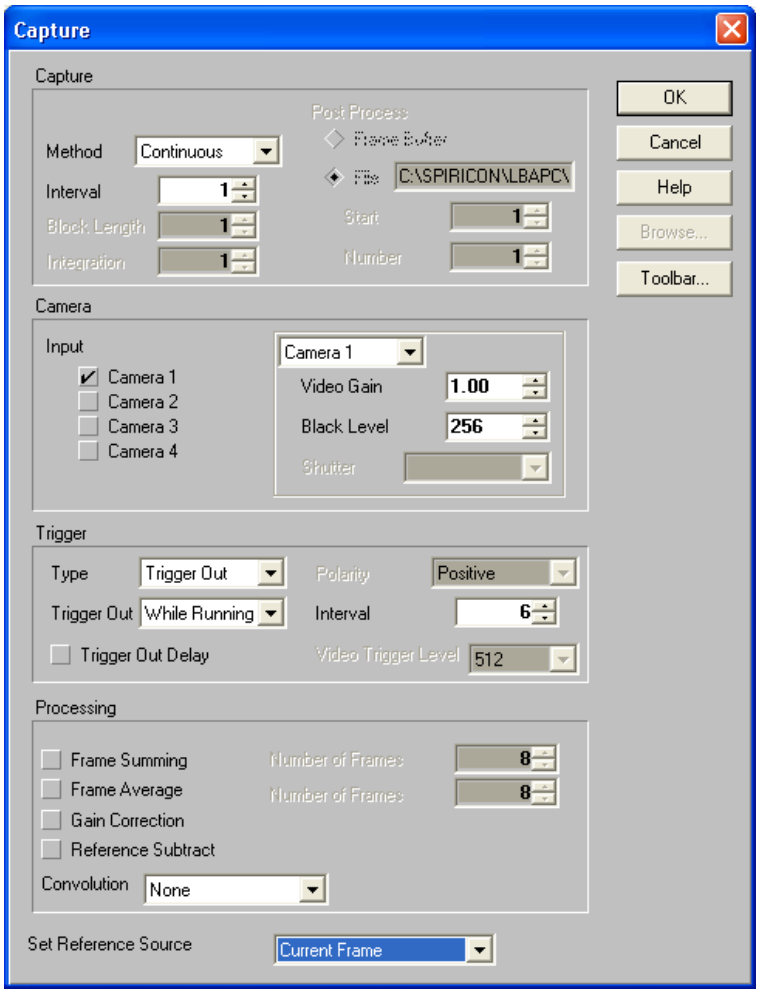


Figure 17

The user can assign certain of these capture control items to the **Capture Toolbar**. The assigned items will appear on the toolbar in essentially the same order that they are listed in this dialog box. The operation of each item from the Toolbar is identical to their operation from this dialog box. For simplicity, the following examples will refer only to the dialog box entries. Toolbar switch icons will be included in the titles when they exist.

3.2.4.1 Capture

The **Capture** panel controls how imaged data is to be acquired and saved into the frame buffer. You must first choose a capture **Method**, then subsequent selections need to be made. The capture Methods are:

- **Continuous:** Configures the LBA to continuously acquire new frames of video images from the frame grabber card as fast as possible, or at a rate determined by the value set in the **Interval** edit control. (See 3.2.4.2)
- **Single Shot:** Choose if you only want to acquire a single frame of video from the frame grabber card. Each time you click on **Start!**, the frame grabber will capture one video

frame, and then **Stop!**. Successive clicks on **Start!** will each cause one additional frame to be acquired. The **Interval** setting has no effect.

- **Block:** This method will cause a **Block Length** specified number of video frames to be acquired from the frame grabber. What is unique to this method is that the frames will not be displayed, nor have results computed during the acquisition time. This is so the frame grabber can capture frames contiguously, with no delays or lost frames owing to time spent performing results computations. When acquisition of the **Block** of frames is completed, the last frame acquired will be displayed and the results computed for that frame.

*Note: If you specify a **Block Length** larger than the frame buffer capacity, the data will wrap the buffer and overwrite the earlier frames. The Interval setting is operational.*

If you are using **Block Mode** in combination with **Logging** or **Statistics** computations, you should read Implications of Combining Logging Statistics. . . in Section 3.1.12.

- **Live Video:** This is a raw video display only method. Video frames will be continuously acquired based upon the **Trigger Type** selection and the **Interval** setting. However, the data will be totally unprocessed, will not be placed into the frame buffer, and will yield no computed results. This is best described as the... "is my camera/frame grabber working?" mode. When you are in the **Live Video** mode, the **Frame** indicator will be forced to a **-6**, and the Frame Comment will be forced to read **Live Frame**.

Note: This method only operates in **2D** *display mode.*

Hint: It is best to set the Trigger Type to the CW mode when using Live Video to locate your laser beam on your camera's detector.

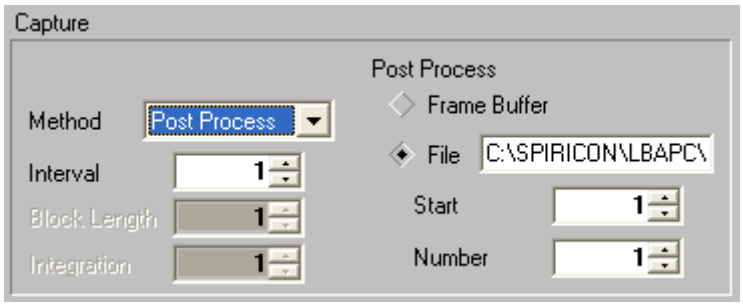


Figure 18

- **Post Process:** This method does not collect video frames from the frame grabber, but rather allows you to run, or rerun, processing of old data that is either already stored in the frame buffer, or stored in a disk data file. When **Post Process** is selected, the right half of the **Capture** panel becomes activated. Click on the **Frame Buffer** radio button to select processing of data already in the frame buffer, or click on **File** to post process data from a **.lb3/4/5/7** data file. If you have selected **File**, type in the file name that you want to source the data from, or click on **Browse...** to search for the file name. In either case, you must specify the **Start** location of either the frame buffer location or the

file record number, and the **Number** of frames or records to post process. The number of frames can be 0, or 1 to the number of frames in the frame buffer or file. 0 means all the frames. The resulting frames will be placed sequentially into the frame buffer, beginning at the current frame buffer location. Be careful that you do not overwrite something you intended to save. The post processing toolbar switch is a shortcut to selecting the above file name.

If you are using **Post Processing** in combination with **Logging** or **Statistics** computations, you should read Implications of Combining Logging, Statistics. . . in Section 3.1.12.

Operating hints:

- When setting up, use the **Continuous** method with **Interval** set to 1.
- Always **Post Process** from a **File** source.
- You cannot use **Post Process** to **Ultracal** old data. It must have been calibrated when it was captured.

3.2.4.2 Capture Interval

The **Interval** setting determines the capture rate, up to the fastest rate achievable under the present setup conditions. The value entered in this edit control specifies how many frames will occur for each frame captured. A setting of 1, will attempt to capture every frame from the camera; 2, will capture every second frame; 3 every third; and so on...

Divide this setting into the camera frame rate to compute the rate at which the system will attempt to digitize frames, i.e., a 3 will cause a 30 Hz frame rate camera to be digitized at 10 frames per second. The ultimate impact of this setting is also determined by the **Trigger Interval** setting, see Rate Control in Chapter 5.

Note: The fastest achievable frame rate is determined by other factors, including the image size, the speed of your PC, the type and number of results being computed, the amount of processing being employed.

3.2.4.3 Camera

The **Camera** panel in the **Capture** dialog box permits you to:

- Select which camera **Input** is in use. Note: This choice is only available if you purchased the four-camera option, see section 3.2.4.3.1 below, otherwise the only available choice is Camera 1.
- Set the **Video Gain** level of the signal processing system on the frame grabber card. Note: If you have the four-camera option, this control will apply only to the currently selected camera.
- Set the digitizer **Black Level** threshold. Note: If you have the four-camera option, this control will apply only to the currently selected camera.
- Program the electronic **Shutter** setting of your camera, if your camera is equipped with a remote shutter control feature. Note: If you have the four-camera option, this control will apply only to the currently selected camera.

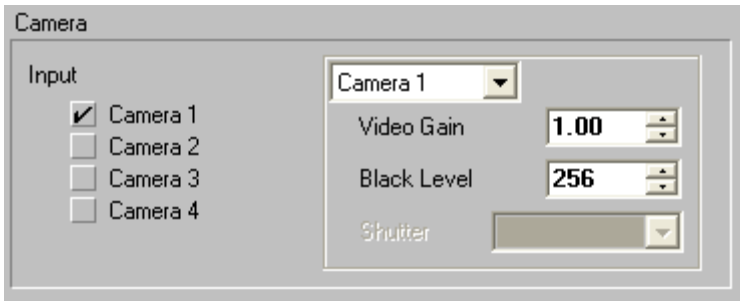


Figure 19

Operating hints:

- Increasing **Video Gain** also increases video noise. Use **Video Gain** sparingly, or not at all. Leave it set to 1 whenever possible.
- The **Black Level** will be adjusted automatically each time you perform an **Ultracal!** calibration cycle. Therefore, it is best that you make no changes to this setting. If you alter the **Black Level** after an **Ultracal!**, the calibration will no longer be valid.

3.2.4.3.1 The Four Camera Option

Some enhancements have been made to the four-camera option with the release of software version 4.00. These enhancements make it possible to automatically sequence data collection between multiple cameras (up to four). This sequencing only applies to analog cameras, and the following operating conditions must be met:

- All cameras must be the same type or model.
- The cameras must be Gen-Locked together.
- If cameras with remotely controlled shutters are used the shutter control circuits must be paralleled to each camera.

The status of the input video is shown in the video enunciator located at the bottom of the LBA-PC's main display window. The number shown in this enunciator indicates which camera is currently selected. If it shows GREEN then camera sync is present. If it shows RED then there is either no camera connected, or the connected camera is not operating.

3.2.4.3.2 How to Specify Video Gain, Black Level, Shutter, and Video Trigger Level

On the right side of the Camera panel you will see a panel containing a **Camera#** drop-down, **Video Gain**, **Black Level**, and **Shutter** controls. Click on the drop-down to select which camera is affected, the current settings are displayed, and then make the desired changes. Note that **Video Trigger Level**, Trigger section below, can also be set for each camera.

On the toolbar, changing the **Video Gain**, **Black Level**, **Shutter**, and **Video Trigger Level** affects only the current camera listed in the video enunciator located at the bottom of the main display window.

3.2.4.3.3 Automatic Camera Switching Using the Four Camera Option

With the four-camera option automatic switching between camera inputs is made possible by checking more than one camera enable at a time. Input data frames are repeatedly cycled into the frame buffer starting with the lowest numbered camera after clicking **Start!**

Example: If cameras 1, 3 and 4 are checked; data will be placed into the frame buffer sequentially from camera 1,3,4,1,3,4…, etc. Clicking **Stop!** will halt data collection at whichever camera last input data into the frame buffer.

WARNING: Do not check on a camera unless a camera is actually connected to the indicated camera input. An enabled input without a camera will cause data collection to stall when the nonexistent camera is selected.

.

3.2.4.3.4 Ultracal Operation with the Four Camera Option

If more than one camera is checked on when the **Ultracal!** menu item is activated, each of the enabled cameras will be separately Ultracal'd in rotation. Data collected from each camera will be individually baseline corrected according to its respective Ultracal reference frame.

3.2.4.3.5 Auto-Exposure Operation with the Four Camera Option

The Auto-Exposure feature will automatically set the exposure or electronic shutter of certain compatible types of cameras. If the four-camera option is present the LBA application will attempt to find a correct shutter setting for each enabled camera. It will apply the correct shutter setting to each camera during the data collection process.

3.2.4.3.6 Acquisition Rate Effects with the Four Camera Option

The data acquisition rate, when cycling between cameras, will depend upon the number and types of enabled processing features. Without any processing overhead the camera switch rate is the frame rate of the camera. This means that if one camera can be input at 30 frames per second, then camera switching will progress at 30 switches per second. If your system is not capable of sustaining this rate, then the resulting rate will be whatever maximum rate can be sustained.

When various types of image processing, or complex computations are being performed, the acquisition rate may slow down. These effects will delay the switching rate accordingly. The rule affecting the switching rate is that it will take as long to switch to the next camera as it takes to acquire and process data for the current camera.

Note: Image processing rules apply identically to the data inputs of all enabled cameras. I.e. If frame averaging is enabled then each camera input will be frame averaged before switching to the next camera. It is not possible to average inputs from multiple cameras during the data collection process. However this can be done using the Post Processing feature.

3.2.4.4 Trigger

The **Trigger** panel in the **Capture** dialog box allows you to selectively control when an image is to be captured by the LBA. The selected trigger **Type** will govern which of the other selections you will need to make. The four **Type** choices are:

- **CW:** Choose this type if your laser operates in a continuous wave manner, or pulses at a repetition rate that will appear to your video camera as continuous. In **CW** mode, none of the other settings in this panel are applicable.

- **Trigger Out:** If your laser is a pulsed type, and you would like the LBA-PC to provide an output pulse that will cause the laser to be fired, use this setting. See Trigger Out and Interval and Trigger Out Delay.
- **Video Trigger:** With this mode selected, the input from your camera is continuously monitored, and when a laser pulse is detected, the frame is captured. The pulse detector has a programmable threshold that is settable in the **Video Trigger Level** edit control. The level setting is always in raw digitizer counts. A suggested trigger level value, that will not detect noise yet remain reasonably sensitive, is the second lowest level.
- **Trigger In:** If your laser can provide a compatible trigger input pulse to the LBA, then you can use that pulse to synchronize the capture of your video frame. In general, this technique is inferior to the preceding **Video Trigger** mode. Its only advantage would be to allow you to capture an event that occurs independently of other things that might be occurring in the video frame that preclude the use of **Video Trigger**. See **Polarity**.

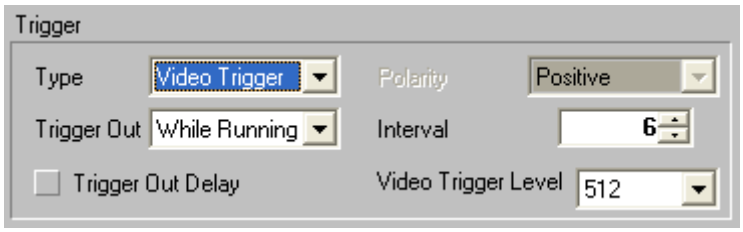


Figure 20

The other settings operate and apply as follows:

- **Trigger Out:** Applies to **Trigger Out** and **Video Trigger** modes. Output pulses from the LBA-PC can be programmed to output **Always**, or only when the frame grabber is sampling video **While Running**. i.e., beginning when you click **Start!**, ending when you click **Stop!** Note: The output trigger pulse is always positive and its pulse width is fixed (see Specifications).
- **Interval:** Applies to **Trigger Out** and Video **Trigger modes**. You can program the rate at which the LBA will produce trigger output pulses. The rate is based upon the camera frame rate. The value entered in this edit control specifies how many frames will occur for each trigger pulse generated. A setting of 1, will output a trigger pulse once for every frame of the camera; 2, will output a pulse on every second frame; 3 every third; and so on... Divide this setting into the camera frame rate to compute the rate at which the LBA will output trigger pulses. i.e., a 3 will cause a 30 Hz frame rate camera to fire a laser at 10 frames per second.
- **Trigger Out Delay:** Applies to **Trigger Out** and **Video Trigger** modes. If this item is not checked, the trigger output pulse will occur at the same time as the camera's vertical sync, i.e. at the start of each video frame. For many CCD cameras, this is not a good time to receive a laser pulse. If you check this item, the trigger output pulse will be delayed to a time near the middle of the video frame, or field, if the camera is interlaced.
- **Polarity:** Applies to the **Trigger In** mode only. The LBA response to a trigger input is edge sensitive. You can program the response to the input trigger pulse to be either **Positive**, rising edge sensitive, or **Negative**, falling edge sensitive.

See Chapter 5 for additional information and examples regarding Triggering.

3.2.4.5 Processing

The **Processing** panel is where you select how to process digitized frames of data. This processing determines how each frame that is stored in the frame buffer will be constructed. This processing occurs prior to the calculating of any numerical results.

Figure 21

The **Processing** options are applicable to both newly input frames from the frame grabber card, and to recorded frames that are being **Post Processed**. Below this panel you can also select the source for reference frames.

Figure 22

When enabled, the precedence of all processing and post processing operations are as follows (lowest number occurring first):

1. Ultracal Processing (can not be post processed)
2. Gain Correction
3. Gamma Correction
4. Frame Summing
5. Frame Averaging
6. Reference Subtraction
7. Convolution

Although Ultracal is a processing step it is important to note the following:

- Ultracal processing of newly acquired video is not an option in the dialog above.
- Ultracal processing must be enabled from the main screen Menu bar.

- Ultracal processing cannot be a part of a post processing operation.

Gamma Correction is also a type of processing. **Gamma Correction** is controlled from the **Camera** dialog box, as it relates to a specific camera's characteristics. **Gamma correction** can be part of a post processing operation.

3.2.4.6 Frame Summing

Click on this item if you want the LBA to sum frames. Specify the **Number of Frames** that you want to sum into each frame placed in the frame buffer. Frames are always summed in the order that they are input. Frame summing can be used to increase the apparent size of low-level signals. Fixed pattern noise will unfortunately grow linearly with each summed frame, but temporal noise will increase at approximately the square root of the number of frames summed, thus the resulting signal to noise ratio will be improved.

3.2.4.7 Frame Average

Check on this item if you want the LBA to average frames. Specify the **Number of Frames** that you want to average into each frame placed in the frame buffer. Frames are always averaged in the order that they are input. Frame averaging will improve the signal to noise ratio by approximately the square root of the number of frames averaged.

Note: If the frame that you are averaging has poor pointing stability, then the reliability of the computed results of an averaged frame may not be very good.

3.2.4.8 Gain Correction

Check on this item if you want to apply **Gain Correction**. You must have Generated or Loaded a gain correction table, before you can apply gain correction processing to newly acquired or post processed frames of data. See 3.1.8 Generate Gain, for further details.

3.2.4.9 Reference Subtraction

Check on this item if you want to subtract the reference frame from newly acquired or post processed frames of data. The reference frame is location 0 (zero) in the frame buffer. This location is always reserved for the reference frame. The content of frame 0 will be subtracted from the results of all other processing operations. Associated with creating and saving a reference frame is the **Set Reference Source** edit control (shown above), and the **Set Reference** action item in the **Files** menu, and the set reference toolbar button. See Set Reference for further details.

The **Set Reference Source** edit control allows you to select what type of data will be loaded into the reference frame.

Using this feature with the four-camera option will cause the reference frame to be subtracted from the input of each camera. It does not discriminate between camera selections.

*Note: This edit control is repeated in the **Beam Display** dialog box and is available in the Display Toolbar.*

- If the **Set Reference Source** item is set to **Current Frame**, the data in the currently viewed frame will be copied to the **Reference** frame.
- If the **Set Reference Source** is set to **Last Gauss**, and the **Gauss Fit** item in the **Computations…** dialog box is checked, then the beam profile resulting from a computed Gaussian fit to the currently viewed frame will be copied to the **Reference** frame.
- If the **Set Reference Source** is set to **Auto Gauss**, and the **Gauss Fit** item in the **Computations** dialog box is checked, then the beam profile resulting from a computed Gaussian fit to newly acquired frames will be automatically copied to the **Reference** frame. In this mode, setting a reference frame manually does not make any sense because the next frame brought into view will automatically update the contents of the reference frame.

Note: In the last two examples, if the **Gauss Fit** *item is not Checked, then no fit is computed and thus no data will be copied to the* **Reference** *frame.*

3.2.4.10 Convolution

The term **Convolution** indicates a type of two-dimensional spatial filtering that can be applied to a digitized image. We will not attempt to use this term in any restricted construct. Rather we will apply it generally to a variety of area process transformations. At the time of this release we are providing just a few convolution algorithms, these primarily aimed at simple low-pass spatial filtering. We expect this list to grow in time, and welcome suggestions from our users for additional implementations.

Click on this edit control to see a list of **Convolution** algorithms. Entries in this list that begin **LPF #**, indicate a Low-Pass filter. This is the most commonly used algorithm for simple image smoothing operations. The numbers following define the size of the convolution kernel in pixels. For example, 3x3 indicates a 9 pixel kernel 3 pixels by 3 pixels. Other common sizes are 5x5 and 7x7.

We recommend that you experiment with these selections until you find a process that meets your specific needs.

See Convolution in Section 6.27 for more details regarding how these algorithms are applied.

3.2.5 Capture Toolbar… design the toolbar contents

You can select which functions you want to appear on the Capture Toolbar by checking the desired item. The functions will appear on the toolbar in the same order that they are listed in this dialog box. The first four panels; **Capture**, **Camera**, **Trigger**, and **Processing**, are analogous to the items listed in the Capture dialog box.

The panel labeled **Other** offers you the following two tools that are associated with File menu items, and a third item that is not available anywhere else.

3.2.5.1 Logging

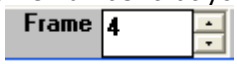
This switch will launch you into the **Data & Results Logging** dialog box.

3.2.5.2 Print

This switch will cause the selected print options to be printed on your configured printer. You will not get a chance to reconfigure your printer or print setup item when you click this tool, so be sure that you have set your options up in File, Print Setup... before you click here.

3.2.5.3 Write Protect

This tool can be used to write protect any frame in the frame buffer. Before clicking on this tool, be sure that the frame number that you want to write protect is indicated in the frame counter.

The frame counter 

is located in the lower right corner of the main window. When a frame has been write protected, its location in the frame buffer can not be overwritten. When new data is flowing into the frame buffer, write protected locations will be skipped.

To un-write-protect a location, bring the frame number up again and note that the write protect button is still in the depressed position; click the tool a second time. This tool's button will show in the un-depressed state to indicate that the frame is no longer write-protected. Therefore, the only way to determine which frames are write-protected is to cycle through the frames and simultaneously view the up/down state of the write-protect button.

Caution: If you change the frame buffer resolution, all write protected frames and their contents will be deleted.

3.2.6 Computation... Energy calibration select results items

The **Computations** dialog box is where you select the types of numerical results that you want to have calculated and displayed. You can also calibrate the beam energy here.

*Note: The term **energy**, shown in Italic, will be used to represent both Energy and Power.*

3.2.6.1 Energy of Beam

The **Energy of Beam** edit control item lets you calibrate the LBA to the *energy* of your laser. You must measure the *energy* of your beam using an external measuring device, then enter the *energy* value here. Next select the appropriate units in the ***Energy* Units** item. The value entered must be the total *energy* of the frame currently displayed. For accurate results, the beam must be completely contained inside the current Hardware Zoom/Pan window, and an **Ultracal!** operation should be performed prior to collecting the frame used for *energy* calibration.

Figure 23

If you enter an **Energy of Beam** value of 0 (zero) the *energy* related results items, such as, **Total** (*energy*), **Peak** (fluence), **Min**, **Gauss Height**, etc., will be computed in processed digitizer units. Processed digitizer units are called counts, and are dimensionless. In this case, no units will be displayed in the results window.

Any non-zero entry will cause the displayed results to be reported in the units selected. Fluence results will also rely upon the **Pixel Units** entry to complete the energy density definition. A **Pixel Unit** selection of **PX** stands for pixel spatial units. The **PX** unit is dimensionless.

When the **Scale Units** are set to **µm**, **mm**, or **cm**, the *energy* density results are computed as *energy*/cm². When the scale units are set to **PX** or **m**, the density results are displayed as *energy*/PX², or *energy*/m² respectively.

3.2.6.2 Energy Calibration Procedure

After you have set up the LBA-PC and are ready to acquire data, the *energy* calibration procedure involves the following three operation:

1. Execute an **Ultracal!** operation.
2. Acquire a calibration frame on the 2D display and a matching *energy* measurement on an external power/energy meter.
3. Enter the *energy* and select the units in the **Computations** dialog box.

3.2.6.3 Quantitative display, on/off

Check the Quantitative box if you want to have the quantitative results item appear in the results window. Checking this box only controls the display of these results. Even if not checked, these results will be computed. The only way to turn off all computational activity is to minimize the Results display window. The displayed quantitative results consist of the following:

- **Total** *energy*
- **% in Aperture**
- **Peak** fluence
- **Min**
- **Peak Loc**..ation, in **X** and **Y**
- **Centroid** location, in **X** and **Y**
- Beam Width, in both **X** and **Y** or **Major** and **Minor** axes
- Beam **Diameter**

For a detailed discussion of the above items see Chapter 4, Results Display, and Chapter 6, Computations.

3.2.6.4 Beam Width Method

The **Beam Width Method** edit selection will determine the technique used to compute the beam width results. The first two methods (**4 Sigma and 90/10 Knife Edge**) are computed based upon industry standard definitions. The remaining three choices are user definable, so use care in setting up and restoring their related options. See Beam Widths and Diameters in Chapter 6 for a technical discussion of the methods described here.

*Notice: **Beam Width** measurements should never be made without **Ultracal!** processing. Failure to perform an **Ultracal!** operation will most certainly lead to inaccurate beam width results.*

*Note: The **Diameter** results are always computed as the mean of the two **Beam Width** results.*

The five Beam Width Methods are:

- 4 Sigma
- 90/10 Knife Edge
- Knife Edge (user definable)
- Percent of Energy (user definable)
- Percent of Peak (user definable)

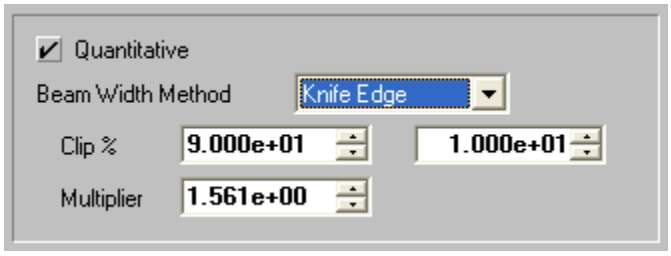


Figure 24

3.2.6.4.1 D4 Sigma

The **4 Sigma**, or second moment method, will directly compute second moment beam widths in the **X** and **Y** beam axial directions, or along the computed orthogonal **Major** and **Minor** axes of the beam if the **Elliptical** calculations are enabled. The **4 Sigma** method should always be used in conjunction with the LBA's **Auto Aperture** feature. The **4 Sigma** method is most sensitive to noise. If your camera or beam noise content is high you might want to employ **Frame Averaging** or **Statistical** analysis to home in on more accurate results. A big advantage of this method is that it is not influenced by mode content.

3.2.6.4.2 90/10 Knife Edge

This **Knife Edge** method uses a fixed 90% and 10% of energy as the moving edge **Clip%** points. The correction **Multiplier** is fixed at 1.561. These settings will yield highly accurate second moment equivalent beam widths for beams that are predominantly TEM_{00} in mode content, and for many other mixed mode combinations. There are a few modes for which this method will not be as accurate, as well as Top Hat shaped beams. This method will compute beam widths in the **X** and **Y** beam axial directions, or along the computed orthogonal **Major** and **Minor** axes of the beam if the **Elliptical** calculations are enabled.

3.2.6.4.3 Knife Edge

If your laser mode content is not suitable for measurement using the previous **Knife Edge** method, then you can use this method and program your own **Clip** and **Multiplier** factors. For example if your beam is almost a pure donut shape (TEM_{01}*), use the previous **90** and **10 Clip%** setting, but change the **Multiplier** to 1.533. For a circular Top Hat, use a **Multiplier** of 1.455. For a square Top Hat use a **Multiplier** of 1.444. This method will compute beam widths in the **X** and **Y** beam axial directions, or along the computed orthogonal **Major** and **Minor** axes of the beam if the **Elliptical** calculations are enabled.

Hints: In general, your two Clip level settings should add up to 100%. Avoid using clip levels of <10%, as this begins to approach the camera's noise floor, especially if your beam peak energy is less than 20% of camera saturation.

3.2.6.4.4 Percent of Energy

This method will only use a limited amount of your beams energy to compute beam widths. In particular, it will only use the data from pixels on the **X** and **Y** axes of the beam that pass nearest to the computed centroid. If you have the **Elliptical** computations enabled, then the data used for this calculation will be from those pixels that lie along the **Major** and **Minor** axes. The **Percent of Energy** method requires that you set a **Clip %** value that corresponds to the percent of energy that will be used to define the beam width. For example, set the clip value to 86.47% if your beam is mostly a Gaussian TEM_{00} mode. The resulting beam widths will then be a $1/e^2$, or second moment equivalent value.

3.2.6.4.5 Percent of Peak

This method will only use a limited amount of your beam's energy to compute beam widths. In particular, it will only use the data from pixels on the **X** and **Y** axes of the beam that pass nearest to the computed centroid. If you have the **Elliptical** computations enabled, then the data used for this calculation will be from those pixels that lie along the **Major** and **Minor** axes. The **Percent of Peak** method requires that you set a **Clip %** value that corresponds to the percent of your beams peak that will be used to define the beam width. For example, set the clip value to 13.53% if your beam is mostly a Gaussian TEM_{00} mode. The resulting beam widths will then be a $1/e^2$, or second moment equivalent value.

Hint: This method is most useful to measure the widths of Top Hat beams typically based upon a Full-Width-Half-Max (FWHM) criteria. To achieve this set the **Clip%** *to 50%.*

3.2.6.5 Elliptical

Check on the **Elliptical** box to cause elliptical calculations to be performed. Having **Elliptical** results enabled will cause the nature of other calculations to be modified. In particular, **Beam Width** results will now be computed based upon the orientation of the **Major** and **Minor** axes of the beam, instead of the **X** and **Y** axes, as will the aligned **Gauss Fit** and **Divergence** results. See Elliptical in Chapter 6 for additional details.

3.2.6.6 Gauss Fit

Check on the **Gauss Fit** box to cause the Gaussian fitter results to be displayed. Gauss Fit computes a best fit of a Gaussian distribution to the data. Two types of fits are available. One is **Whole Beam**, and the second is **X/Y** or **Major/Minor** aligned. The **Whole Beam** choice computes an **X,Y** axial aligned fit to all of the data. The aligned choices perform two separate line fits using just the data that passes through the centroid, along the **X,Y** or **Major**, **Minor** axes. See Gauss Fit in Chapter 6 for additional details.

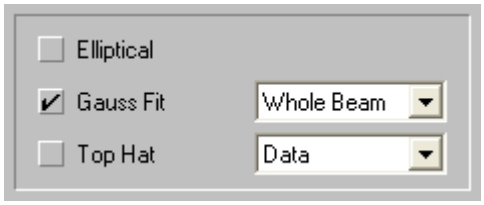


Figure 25

3.2.6.7 Top Hat

Check on the **Top Hat** box to cause the **Top Hat** results to be displayed. **Top Hat** results include **Mean, StdDev, (Std/Mean)%, Min, Max, Top Hat Factor, Effective Area** and **Effective Diameter**. You must choose one of the three methods that determine how the **Top Hat** results are computed. These choices and their affects are:

- **Data**: This method will include all data above the Clip% level. If you are using **4 Sigma**, or one of the **Knife Edge** beam width methods, the Clip% level is forced to 80% of peak.
- **Area Aperture**: Only available if an Aperture is present. This method will restrict the calculations to all data inside the Aperture. The clip level is only used to compute **Effective Area** and **Diameter** and has no effect on the other results.
- **Line Aperture**: Only available if an Aperture is present. This selection causes two separate Top Hat results to be computed along the orthogonal axes of the Aperture. The clip level is only used to compute Effective Area and Diameter and has no effect on the other results.

Notice: If you disable the **Aperture,** *in either the* **Area or Line Aperture** *modes, the above setup will automatically revert to* **Data**.

Hints: Use **Drawn** *apertures and avoid* **Auto** *apertures when making Top Hat measurements. Use* **Percent of Peak** *as your beam width method. Typical Percent of Peak* **Clip%** *settings are 50%, 80%, and 90%.*

Refer to the Top Hat section in Chapter 6 for additional details.

3.2.6.8 Divergence

Two methods are provided for making divergence measurements of your laser beam. The preferred technique is the **Focal Length** method. The **Focal Length** method can produce a valid result anywhere in the laser beam path and only requires one measurement.

A second technique, referred to as the **Far-Field** method, is also provided. The **Far-Field** method is only valid if you are sampling your laser in the far field. It will give incorrect results if you are measuring your laser in the near-field. The Far-Field method requires you to make two sets of beam width measurements a known distance apart.

See Divergence in Chapter 6 for details regarding how these two methods are computed.

3.2.6.8.1 Focal Length Divergence Measurements

The **Focal Length** method requires you to bring your laser beam to a focus using either a focusing lens or mirror. You must place your camera detector at the focal point of the focusing optic. One-half to one-meter focal lengths are typical, as they will keep the focused spot size large enough to be measured with a CCD camera.

Check the **Divergence** box and select **Focal Length** in the drop down edit control. Enter the Focal Length of your optical system in **meters**. The divergence results will be computed for both the **X** and **Y** or the **Major** and **Minor** beam widths, depending upon Elliptical being enabled.

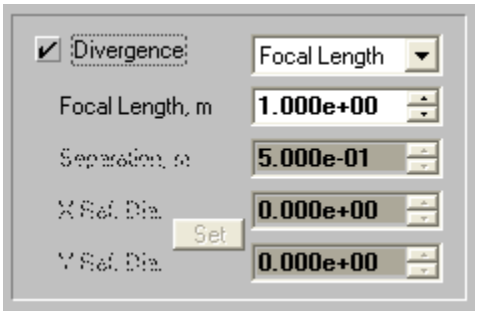


Figure 26

The **Focal Length** method is most appropriate for lasers that exhibit small angular divergences. For larger divergence angles, like those seen with laser diodes, the **Far-Field** method is much more accurate.

3.2.6.8.2 Far-Field Divergence Measurements

The **Far-Field** method requires you to measure the beam widths of your laser at two known locations in the beams far-field. The change in size is used to compute the rate of beam divergence in mili-radians.

First collect a pair of **Reference** beam widths. The **Reference** data should be acquired at the smaller beam width location. Click **Stop!**, and note the location of your camera in the beam path.

Open the **Options...Computations** dialog box. Check the **Divergence** box and select **Far Field** in the drop down edit control. Click the **Set** button to transfer the current Reference beam widths into the provided edit control boxes.

Note: You can manually enter these values from a previous measurement if you know what they are. The **Set** *button is provided to facilitate making this entry.*

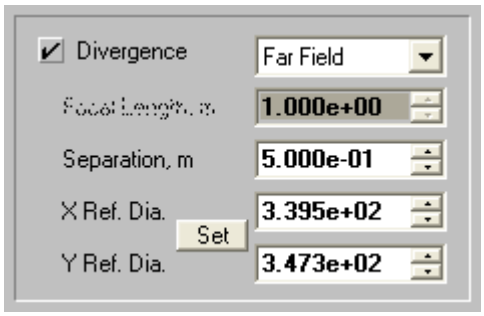


Figure 27

Move your camera to the larger beam width sample location, noting the distance traveled by the camera. The distance traveled is the separation distance between the two sample locations. Enter this **Separation** distance in **meters**. Click **OK** and then **Start!** The divergence results will be computed for both the **X** and **Y** axes based upon how the current beam size has increased from that of the **Reference** sample.

Notice: It is not recommended that **Elliptical** *be enabled when making this measurement, rather you should rotate your laser/camera to be X and Y axis aligned. Under certain conditions the rate of divergence could cause the major and minor axes to swap in the far field region, yielding false results.*

3.2.6.9 Histogram

Check this box if you want to view a **Histogram** of your laser beam's energy distribution. The **Histogram** graphic and numerical results will appear in its own window of the LBA's main display. The size of each bucket in the histogram is user programmable. Bucket size is based upon the integer values produced by the A to D converter. If required, the bucket size will be converted to floating point values to reflect the processing effects of an energy calibration. The buckets are sized up (plus) and down (minus) from zero.

Figure 28

Enter the **Bucket Size** in the provided edit control. A good value to start with is 16, 64, 256 or 1024, depending upon which model frame grabber you are using; an 8, 10, 16, or 14 bit format respectively.

Refer to the Histogram section in Chapter 6 for additional details.

3.2.6.10 Statistics

Check this box to enable the addition of Statistical information in the Results window. Statistical results will be computed for every numerical results item that is appearing in the Results window. The statistical results provided are**: Mean, Standard Deviation, Maximum**, and **Minimum**. To view the statistics results you must either maximize the Results window, or use the horizontal scroll bar to bring the values into view.

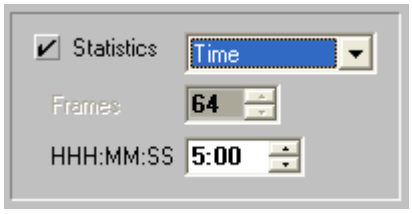


Figure 29

There are three ways to control how many samples are used to generate the statistical results calculations. The following choices and their usage is as follows:

1. **Continuous**: Statistical results will begin to accumulate when you click Start!, and do so until you click **Stop!**.
2. **Frames**: Enter the number of frames of data that you want to accumulate for statistical purposes. After you click **Start!** the LBA will run until the number of frames is collected and then automatically **Stop!**.
3. **Time**: Enter the collection duration in Hours:Minutes:Seconds that you want to accumulate statistical results. After you click **Start!** the LBA will run until the time is depleted and then automatically **Stop!**.

In all of the above, you can click **Stop!** and click **Start!** to pause and to resume statistical data collection. However, in cases 2 and 3 above, when you restart, it does not resume the cycle

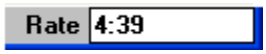
from the point of interruption. Rather the cycle resets to the duration values set in the dialog box, but does not clear the prior accumulated stats.

If you click on **Start!** after the frame count or timer has run out, the collection process will continue to add more data to the results until the cycle completes a second time.

To reset statistical data operations you must turn **Statistics** off, click **OK**, and then turn **Statistics** back on. Or right click in the **Results** window and click on the **Results Statistics** item.

When collecting **Frames** or **Time** limited Statistics, the **Rate** display will indicate the number of frames to go,

or the time remaining



If you are using **Statistics** computations in combination with **Logging**, **Block Capture**, or **Post Processing**, you should read Implications of Combining Logging, Statistics. . . in Section 3.1.12.

Refer to the Statistics section in Chapter 6 for additional information

3.2.7 Beam Display… define the beam display

The LBA-PC has a number of display options. The operation of these options can vary depending upon whether the 2D or 3D display mode is in effect. Options in the **Beam Display** dialog box that are shared by both 2D and 3D modes will be discussed first. Separate sections are provided for those options that are exclusive to either the 2D or 3D panels.

The user can assign certain of these display control items to the **Display Toolbar**. The assigned items will appear on the toolbar in essentially the same order that they are listed in this dialog box. The operation of each item from the Toolbar is identical to their operation from this dialog box. For simplicity, the following examples will refer only to the dialog box entries. Toolbar switch icons will be included in the titles when they exist.

- Beam View
- Cursors
- Cursor Orientation
- Origin Location
- Beam Colors
- Z Axis Scale
- Beam Display
- Set Reference Source
- Display Thresholds
- Color Bar
- Copy Image to Clipboard
- Copy Image to Wallpaper

3.2.7.1 Beam View

Inside the **Beam Display...** dialog, click either the 2D or 3D radio button for the display mode that you want to view your beam in. You may also toggle beam display with the 2D/3D button on the toolbar.

Note: In general 3D displays will run slower than 2D owing to the amount of computations involved with generating the wire frame.

3.2.7.2 Cursors

You may choose to place cursors onto either a 2D or 3D display. The cursors will appear as two black and white dashed lines in a 2D display and as solid white lines in a 3D display. Cursor options include:

- **Off**: No Cursors will be displayed.
- **Manual**: Cursors will be displayed, and the operator manually determines their location.
- **Centroid**: Cursors will be displayed, but their location is automatically drawn to pass through the computed centroid of the beam.

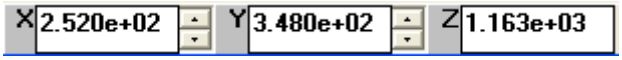
*Note: This operation will revert to **Manual** if the results window is minimized.*

- **Peak**: Cursors will be displayed, but their location is automatically drawn to pass through the peak energy location of the beam.

Note: This operation will revert to **Manual** *if the results window is minimized.*

There are two ways to move and position the Cursors in the 2D display mode, and only one way to move them in the 3D mode.

At the bottom of the main display window are two spin controls, one labeled X: and one Y:.



These controls indicate the location of the Cursor's intersection. The **Value:** displays the *energy* at the Cursor's intersect point. You can edit these controls to redraw the cursors to a new location.

Note: The above method is the **only** *way to move the cursors in the* **3D** *display mode.*

The second way to move the Cursors is to use the mouse to drag and drop them. Move the mouse pointer to the intersection of the Cursors. When the pointer changes to the cursor drag symbol, press and hold down the left mouse button and drag the Cursors to a new location. Release the mouse button to drop the Cursors.

The Cursors can also used to fix the Manual Origin Location. (See 3.2.7.4)

3.2.7.3 Cursor Orientation

The Cursors can be orientated to align with either the **X/Y** axial directions, or with the computed **Major/Minor** axial directions.

*Note: You must have the **Elliptical** computations turned on to permit the* **Major**/**Minor** *orientations to operate correctly, otherwise it will revert to the **X/Y** operating mode.*

3.2.7.4 Origin Location

The beam display window will always have an X/Y origin from which all other positional data will be referenced. A red dot visible in the Pan/Zoom window will indicate where the Origin location is set. The operator can choose one of four defaults, or manually locate the origin. The four defaults are:

- **Detector UL**: The origin will be the upper left-hand corner of the camera detector as referenced in the display Pan/Zoom window.
- **Detector LL**: The origin will be the lower left-hand corner of the camera detector as referenced in the display Pan/Zoom window.
- **Window UL**: The origin will be the upper left-hand corner of the Pan Window as referenced in the display Pan/Zoom window.
- **Window LL**: The origin will be the lower left-hand corner of the Pan Window as referenced in the display Pan/Zoom window.

*Note: In the first two selections, the **Origin** is **absolutely** referenced to the camera detector, and thus the **Pan** window moves over the coordinate system just as the cursors do. In the last two selections the **Origin** is located only with respect to the **Pan** window, thus the **Origin** moves **relative** to the detector as the Pan window is moved.*

Manual origin locations are always absolutely referenced to the camera detector, see note above. You must be in **2D** display mode and have the **Cursors** enabled to manually place the origin. Move the **Cursors** to the location where you want the **Origin** be placed, then **double click the right mouse button**. Observe that the **X:** and **Y:** cursor locations now show zeros. Also observe that the **Pan/Zoom** window's red dot is in the approximate location inside the Pan window where you just placed the Origin.

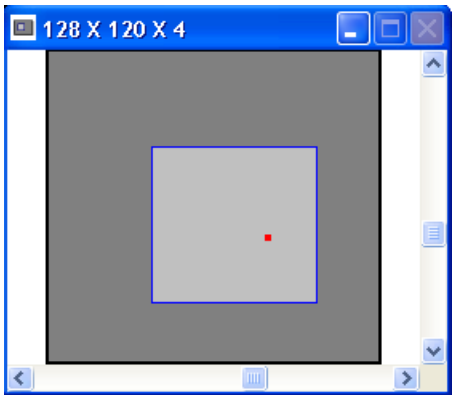


Figure 30

Note: If the **Origin** *is set to* **Manual**, *and the* **Crosshair** *is set to* **Origin**, *then you can move the **Origin** by dragging and dropping the **Crosshair**.*

3.2.7.5 Beam Colors

Your choice of beam display colors depends upon which display mode you have selected. There are 3 choices available in both 2D and 3D modes, plus 2 additional choices in 3D mode. They are:

- **Color Bands**: 16 colors plus white to indicate intensities at, or near, A/D converter saturation. Available in both 2D and 3D.
- **Color Continuous**: 128 colors plus white to indicate intensities at, or near, A/D converter saturation. Available in both 2D and 3D.
- **Gray Scale**: 128 shades of gray plus red to indicate intensities at, or near, A/D converter saturation. Available in both 2D and 3D.
- **Green**: Available only in 3D mode, a monochrome shade of green that can be used with laser goggles that do not filter the green wavelengths. White is used to indicate intensities at, or near, A/D converter saturation.
- **Yellow**: Available only in 3D mode, a monochrome shade of yellow that can be used with laser goggles that do not filter the yellow wavelengths. White is used to indicate intensities at, or near, A/D converter saturation.

Note: In the above selections, data that is representing negative energy values will be displayed in dark gray, except in the case of the gray scale, dark blue.

- **User Palette:** This selection allows the user to select a color palette that they have custom designed. When selected a **Palette** button will appear in the **Display Toolbar**. When you click on this button you will be allowed to select one of your custom palette files for both 2D and 3D displays. See section 3.2.10 about how to create a custom palette.

These basic color schemes can be augmented by some other display choices. In particular, choosing **Z Axis Scaling** greater than **x1**, enabling 3D **Contour** displays, and Beam Display selections that involve more than one beam at a time will modify how your beam will be displayed.

3.2.7.6 Z Axis Scale

You can expand the intensity or **Z Axis Scale** in both 2D and 3D display modes. An expanded Z axis will allow you to view a narrower range of intensities in more detail. The Z axis scaling will yield slightly different imaging results depending upon which Beam Colors you have selected. To activate **Z Axis Scaling**, select a magnification factor greater than **x1**. A good value to practice when using this feature is a conservative **x2**. When Z axis scaling is activated, a vertical scroll bar will appear along the right edge of the beam display window. You can use this scroll bar to slide the expanded viewing range up or down the full Z axis scale.

In **3D** mode, it is easy to see where the expanded display region boundaries end and the outside region begins. To assist you in the **2D** display mode, a pair of dashed lines will indicate the magnified range in the **Cursor Profiles**. Of course, to see these indicators you must have the **Cursor Profiles** turned on and the Cursors passing through the beam profile.

*Hint: Use **Z Axis Scaling** with: Beam Color set to **Color Continuous**, 2D **Cursor Profiles** turned **on**, and **Cursors** set to **Centroid.***

*Another Hint: A good time to use **Z Axis Scaling** is when you need to view the low energy down in the wings of your laser beam. Kick the scaling up to **x8**, leave the scale scroll bar at the bottom of the slider, and maybe add in a little video gain and some **frame averaging** to quiet the noise. You'll be amazed at what you can see!*

3.2.7.7 Beam Display

You can change how your beam is displayed without actually changing how it is processed nor how it is stored in the frame buffer. With these choices you can visually compare your **Current** selected **Beam Display** to a beam profile stored in the **Reference** frame buffer. Or compare it to your beam with the reference added or subtracted from it. Or just display your current beam added to or subtracted by the reference beam.

The choices here seem obvious, however the impact on your display may be a bit disconcerting when first viewed, so some explanation is in order.

First, the definition of **Current** means the frame buffer location indicated in the frame counter at the bottom of the main display window. In other words, the frame you currently have decided to view. If you are running, then the current frame will be cycling.

The **Reference** frame is whatever you last saved into the reference frame buffer, location 0 (zero).

For 99% of the majority of users the **Beam Display** will be set to **Current Alone**, and rarely be changed.

For those other 1%, and you know who you are, read on...

3.2.7.7.1 Current and Reference:

2D You must have both **Cursors** and **Cursor Profiles** enabled for this feature to operate. The Current beam alone will appear in the display. A second profile, drawn in **Lt. Gray** will also appear in the display. This profile is a projection of the Reference beam. All projections are made from the **Cursor** positions.

3D The Current beam will be displayed in **Red**. The Reference will be displayed in **Blue**. If cursors are enabled they will follow the contour of the Current beam.

3.2.7.7.2 Current and Current - Reference:

2D You must have both **Cursors** and **Cursor Profiles** enabled for this feature to operate. The Current beam alone will appear in the display. A second profile, drawn in **Lt. Gray** will appear in the display. This profile is a projection of the Current beam minus the Reference beam. All projections are made from the **Cursor** positions.

3D The Current beam will be displayed in **Red**. The Current minus the Reference will be displayed in **Blue**. If cursors are enabled, they will follow the contour of the Current beam.

3.2.7.7.3 Current and Current + Reference:

2D You must have both **Cursors** and **Cursor Profiles** enabled for this feature to operate. The Current beam alone will appear in the display. A second profile, drawn in **Lt. Gray** will

appear in the display. This profile is a projection of the Current beam plus the Reference beam. All projections are made from the **Cursor** positions.

3D The Current beam will be displayed in **Red**. The Current plus the Reference will be displayed in **Blue**. If cursors are enabled they will follow the contour of the Current beam.

3.2.7.7.4 Reference Alone:

2D You must have both **Cursors** and **Cursor Profiles** enabled for this feature to operate. The Reference beam alone will appear in the display. A second profile, drawn in **Lt. Gray** will appear in the display. This profile is a projection of the otherwise unseen Current beam. All projections are made from the **Cursor** positions.

3D The Reference beam alone will appear in the display. It will be displayed in whatever Beam Color choice was selected.

3.2.7.7.5 Current - Reference:

2D You must have both **Cursors** and **Cursor Profiles** enabled for this feature to operate. The Current minus the Reference beam will appear in the display. A second profile, drawn in **Lt. Gray** will appear in the display. This profile is a projection of the Current beam. All projections are made from the **Cursor** positions.

3D The Current minus the Reference beam will appear in the display. It will be displayed in whatever Beam Color choice was selected.

3.2.7.7.6 Current + Reference:

2D You must have both **Cursors** and **Cursor Profiles** enabled for this feature to operate. The Current plus the Reference beam will appear in the display. A second profile, drawn in **Lt. Gray** will appear in the display. This profile is a projection of the Current beam. All projections are made from the **Cursor** positions.

3D The Current plus the Reference beam will appear in the display. It will be displayed in what ever Beam Color choice was selected.

Note: In all of the above, negative energy results will always be drawn in **dark gray**. *The results computations are only for the Current beam. The displayed image resulting from adding or subtracting reference frames is not saved in the frame buffer, however these images can be printed.*

3.2.7.8 Set Reference Source

The **Set Reference Source** edit control allows you to select what type of data will be loaded into the reference frame. Note: This edit control is repeated in the **Capture** dialog box.

- If the **Set Reference Source** item is set to **Current Frame**, the data in the currently viewed frame will be copied to the Reference frame.
- If the **Set Reference Source** is set to **Last Gauss**, and the **Gauss Fit** item in the Computations dialog box is checked, then the beam profile resulting from a computed Gaussian fit to the currently viewed frame will be copied to the Reference frame.

- If the **Set Reference Source** is set to **Auto Gauss**, and the **Gauss Fit** item in the Computations dialog box is checked, then the beam profile resulting from a computed Gaussian fit to newly acquired frames will be automatically copied to the Reference frame. In this mode, setting a reference frame manually does not make any sense because the next frame brought into view will automatically update the contents of the reference frame.

Note: In the last two examples, if the **Gauss Fit** *item is not checked and set to* **Whole Beam***, then no fit data will be available and therefore nothing will be copied to the* **Reference** *frame.*

3.2.7.9 Display Thresholds

You can add **Display Thresholds** to the beam display that permit you to see when energy intensities fall into regions that may be of significance to your application. You can set a **Lower** and an **Upper** threshold. Setting the **Lower** threshold to zero will disable its operation. Setting the **Upper** threshold to its maximum value will likewise disable its operation. If the **Energy of Beam** setting is set to zero then the maximum value is 255 for the **LBA-300PC**; 1023 for **the LBA-400PC**; 4095 for the **LBA-500PC**. If you have calibrated the beam energy, then the maximum value will be scaled accordingly.

The visual effect of setting active threshold values is to force the displayed beam intensities that fall between the two threshold settings, to follow the **Beam Color** selection. Beam intensities that lie below the **Lower** threshold, or above the **Upper** threshold, will revert to a different color style. Intensities that lie within the threshold region are defined as being in-bounds. Intensities that lie outside the threshold region are said to be out-of-bounds.

If your **Beam Colors** is set to one of the colored selections, i.e., Color Bands, Color Continuous, Green, or Yellow; then the out-of-bounds colors will be replaced with the Gray Scale palette.

If your **Beam Color** is set to the Gray Scale selection, then the out-of-bounds colors will be replaced with the Color Continuous palette.

Hint: Program both the **Lower** *and* **Upper** *threshold values to visually indicate that your Top Hat beam's intensity remains within a certain range. Program just the* **Upper** *threshold value to see if your beam's peak intensity exceeds a certain maximum value.*

Note: Using the **Lower** *threshold feature in* **2D***, combined with a* **colored beam** *selection will have the effect of making your beam profile displays disappear. Use a* **Gray Scale** *selection if you want to preserve the beam profile displays.*

3.2.7.10 Color Bar

If you check the **Color Bar** item, a color-coded Z axis intensity scale will appear along the right-hand edge of the beam display window. This scale will reflect the colors that are currently operating on the beam display. The numerical amounts indicate the intensity value that is required to produce the associated color. Use this only as a guide, unless you have perfect color/gray-scale acuity.

3.2.7.11 Copy Image to Clipboard

If you click on the above button, the currently displayed frame image will be copied to the Clipboard in a .bmp format. This is a handy method for quickly exporting images from the LBA-PC application to another application without having to go through the Export Image process.

3.2.7.12 Copy Image to Wallpaper

If you click on the above button, the currently displayed frame image will be copied to your Desktop Wallpaper. This tool has no real practical application except to provide bored operators with something meaningless to do.

3.2.7.13 2D Only Beam Display Items

The following **Beam Display** dialog box items only affect the **2D** beam display.

3.2.7.13.1 Cursor Profiles

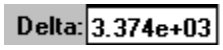
Check this item if you want **Cursor Profiles** to appear along the bottom and left edges of the beam display. The profiles will display a projection of the beam intensity through the pixels where the **Cursors** are drawn. If you have the **Cursors** turned **Off**, no profiles will be displayed.

If your beam display is in color, the profiles will be drawn in White.

If your beam display is in shades of gray, the profiles will be drawn in Red.

The Profile displays will not plot negative values below the noise floor.

3.2.7.13.2 Crosshair

A **Crosshair** mark can be added to the 2D display. You can use the location of the **Crosshair** to make a straight line distance measurement from it to the intersection of the **Cursors**. The distance from the **Crosshair** to the **Cursor** is shown on the lower status bar as the **Delta** 

display. Although the **Crosshair** is not visible in a 3D display, the **Delta** distances are still valid and are based upon how they were last set.

The Crosshair can be configured as follows:

- **Off**: No **Crosshair** will be displayed.
- **Manual**: **Crosshair** will be displayed, and the operator manually determines its location.
- **Centroid**: **Crosshair** will be displayed, and its location is automatically drawn at the computed centroid of the beam.

Note: This operation will not function correctly if the results window is minimized.

- **Peak**: **Crosshair** will be displayed, and its location is automatically drawn at the peak energy location of the beam. Note: This operation will not function correctly if the results window is minimized.
- **Origin**: The **Crosshair** will locate to the position of the **Origin**.

Note: The Crosshair might not be displayed if the Origin location is outside the display window, or it might be in an upper or lower left corner.

To manually position the **Crosshair**, use the mouse to drag and drop it. Move the mouse pointer to the intersection point of the Crosshair.

When the pointer changes to the **Crosshair** drag symbol, , press and hold down the left mouse button and drag the **Crosshair** to a new location. Release the mouse button to drop the **Crosshair**.

The **Crosshair** can also be used to position the **Manual Origin Location**. If the **Origin** is set to **Manual** mode, and the **Crosshair** set to **Origin**, if you drag and drop the **Crosshair** the **Origin** will move with it.

*Note: It is possible for the **Crosshair/Origin** to be outside of the current viewing area of the Display and thus not visible. Check the Pan/Zoom windows red dot to locate the origin.*

3.2.7.13.3 Grid

Check this item to cause an X/Y **Grid** to overlay the display. The **Grid** scale will vary based upon the spatial calibration setting. You can use the **Grid** to make rough distance measurements.

3.2.7.14 3D only

The following **Beam Display** dialog box items only have an effect on the **3D** beam display.

3.2.7.14.1 Wire Frame / Crosshatch

The **3D** beam display is drawn as a wire frame. The above two check items will cause the wire frame display to have wires running only in the horizontal direction, or in a crosshatch pattern. If just the **Wire Frame** item is checked, the display will consist of wires running only in the most horizontal direction. If **Crosshatch** is also checked, the display will be crosshatched. In **3D** mode, either **Wire Frame** or **Contour** (see below), must be checked.

*Hint: Your display will run faster if only **Wire Frame** is checked.*

3.2.7.14.2 Contour

Check the **Contour** box if you want to see your beam display in a contour map style. When you turn on the **Contour** mode the **Wire Frame/Crosshatch** style display will change from

the color style selected to a Light Gray. Only the **Contour** display will remain in the selected **Beam Color**.

Hint: Use the **Color Continuous** *Beam Color type when using the Contour display style.*

3.2.7.14.3 Rotate and Tilt

You can use these edit controls to set the **Rotate** and **Tilt** angles of the X, Y, and Z axes. These controls are a quick way to set specific rotate and tilt values, but the simplest way to change the viewing angles is to use the scroll controls in the **Tilt and Rotate** window.

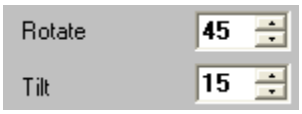


Figure 31

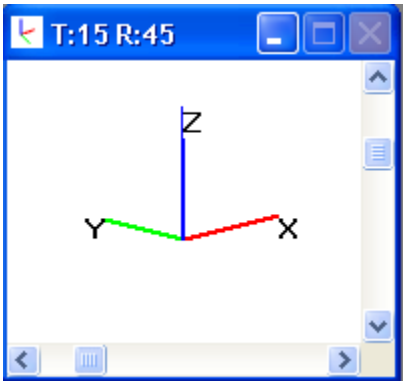


Figure 32

The **Rotate** setting is the direction that the **Red** (X) axis points in degrees. When it points to the right it is at zero degrees. The rotation angle increases at it turns counter-clockwise.

The **Tilt** setting is the angle that the **Blue** (Z) axis makes to the display window. When it points up it's at zero degrees. When it points straight out of the display, it's at 90 degrees.

3.2.7.14.4 Wire Density

The number of wires that comprise the **Wire Frame** display is controlled by the **Wire Density** edit control selection. This setting also controls the **Contour** line resolution. The higher the **Wire Density**, the slower your draw rate. Choose the minimum density that will allow you to see what you need to see.

Figure 33

Note: Whenever you do a Soft Zoom while in 3D mode, the Wire Density will go to the highest resolution value possible, based upon the camera resolution setting. For example, if your camera resolution is 256x240, and your Wire Frame setting is 64x60, the first time you Soft Zoom into the image the wire frame resolution will change to 128x120.

3.2.8 Beam Display Toolbar

You can select which functions you want to appear on the **Display Toolbar** by checking the desired item. The functions will appear on the toolbar in the same order that they are listed in this dialog box.

The three toolbar.panels contain most of the items listed in the **Beam Display** dialog box. **Cursor Profiles** and **Display Thresholds** are not available on the toolbar. The **3D Rotate** and **Tilt** edit controls will appear as scroll bars in a dedicated **Rotate and Tilt** window.

3.2.9 Beam Stability

This program collects centroid and peak data from the LBA-PC and displays it graphically. The graphics that are displayed are as follows:

- A strip chart that collects the following data vs. time. Centroid X and Y, Peak X and Y, and centroid radius from an origin or from the mean centroid.
- A peak location scatter plot with histogram color-coding
- A centroid location scatter plot with histogram color-coding

Click on the **Options** menu item and then click **Launch Beam Stability…** to start the beam stability program. This will open up a new window with the beam stability program that looks like the window below:

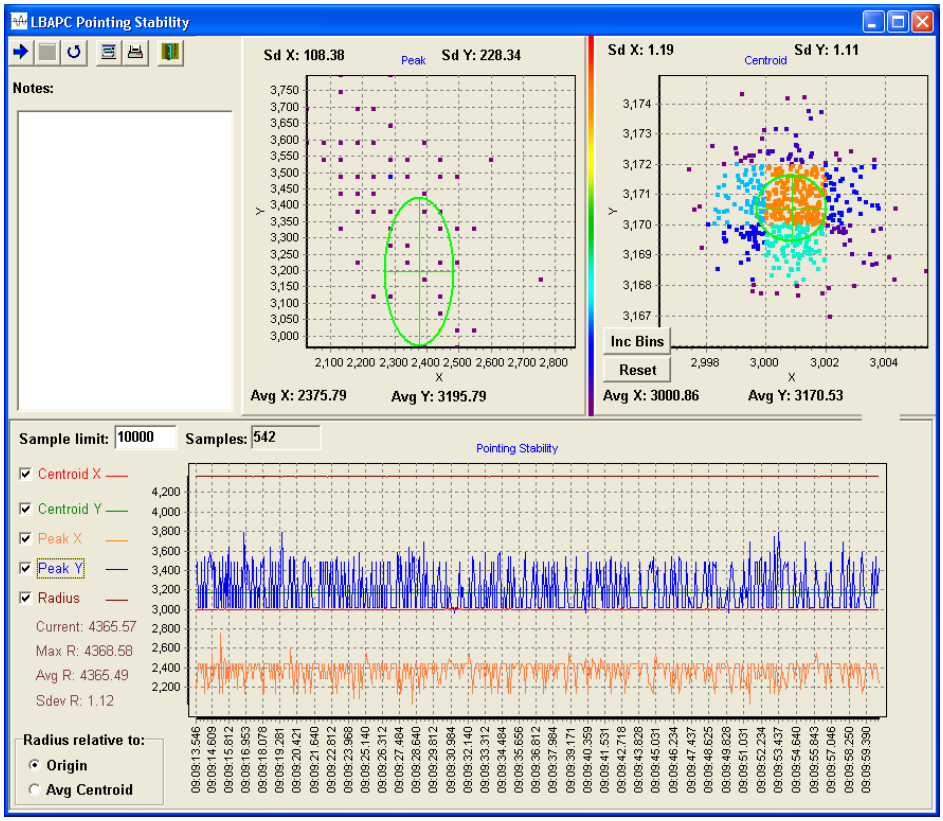


Figure 34

Note: The LBA-PC program must be running, collecting data and non-minimized for the pointing stability program to collect data.

3.2.9.1 Main Controls

The main controls are located in a toolbar in the upper left corner of the main window. These controls consist of buttons for **Start**, **Pause**, **Reset**, **Printer Setup**, **Print**, and **Exit Program**.

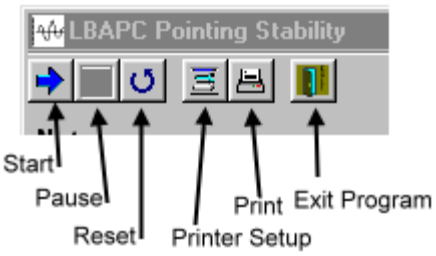


Figure 35

3.2.9.1.1 Start Button

The **Start** Button begins data collection. However, if the LBA-PC is not collecting data in the background, then clicking this button will not result in data being plotted. In order for Beam Stability to work, the user must make sure that LBA-PC is open and collecting data in the background!

3.2.9.1.2 Pause Button

The **Pause** button stops the data graphing but doesn't reset the graphs, thus data is preserved from one pause operation to the next. Clicking on the **Start** button after **Pause** will append data to the graph.

3.2.9.1.3 Reset Button

The **Reset** button will throw away all data in the charts and begin as though the Beam Stability window was just opened. If the user desires to **Print** a run of data it must be done before the **Reset** button is pressed. The text in the **Notes** dialog will not be cleared by the **Reset** operation.

3.2.9.1.4 Printer Setup Button

This is the standard Windows **Printer Setup** dialog box. It allows the user to set up the printer for the desired results.

3.2.9.1.5 Print Button

The **Print Button** causes the entire Beam Stability window to be printed out. The program prints in a "what you see is what you get" manner. The Beam Stability print operation will not print the LBA-PC beam graphic. Printing LBA-PC beam graphics must be done form within the LBA-PC application.

3.2.9.1.6 Notes

Below the Main Controls is a Notes area. The user can type any notations here and it will be printed out with the charts. Information entered here will remain from one reset to the next and from one application startup to the next.

3.2.9.2 Strip Chart Controls

These controls allow the user to configure the way Beam Stability data samples are displayed.

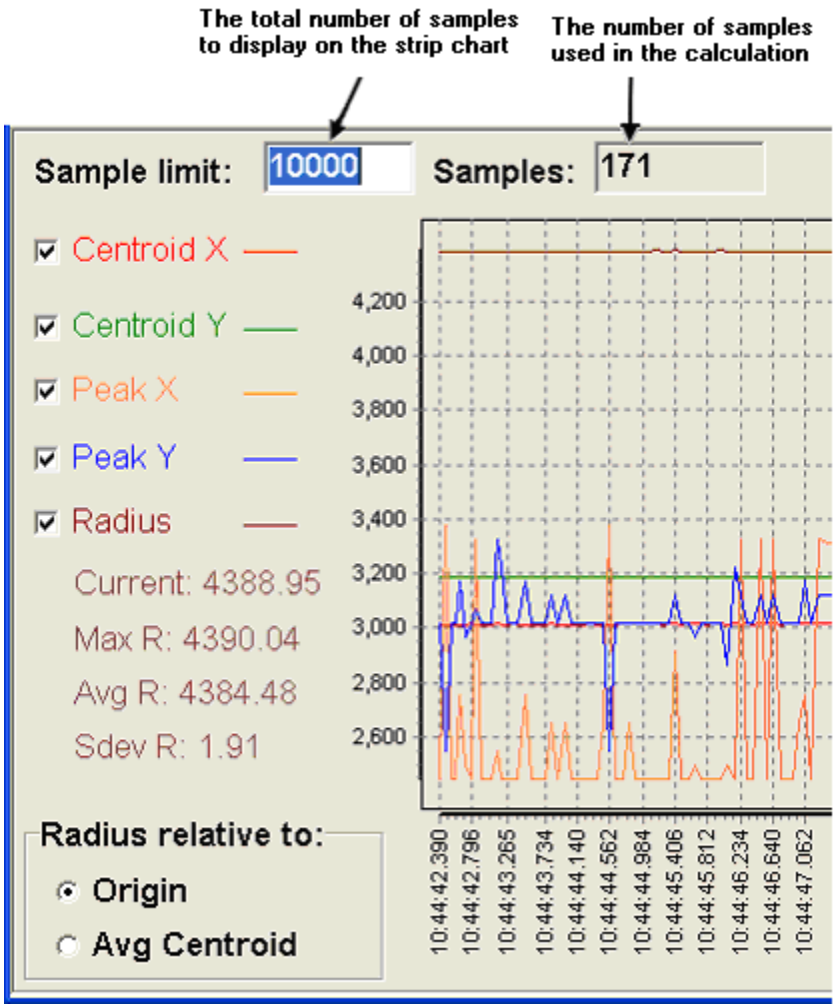


Figure 36

A sample of data is defined as; any results computed from a discrete beam image captured from LBA-PC. The beam stability window will compute it's results based on samples taken from the time the **Start** arrow is clicked, until the beam display is Reset, or until the application is closed and restarted.

3.2.9.2.1 Sample Limit

The strip chart display may become so compact that recent data points become visually indiscernible from the rest of the data in the strip chart. If the user desires to collect several samples, and still focus their attention on the most recent data, it may be necessary to limit the number of displayed samples. **Sample limit** edit box allows the user to specify how many of the most recent samples will be displayed in the strip chart.

Example: If the user has collected samples [1-1000] and the **Sample limit** it set to 100, samples [900-1000] will be the only samples visible in the strip chart. Statistical results will be computed using all the samples [1-1000].

3.2.9.2.2 Samples

The **Samples** indicator shows the total number of samples collected.

3.2.9.2.3 Check Boxes

The **Check Boxes** allow the user to specify what results items are to be graphed on the strip chart. One or all of the following may be selected:

- Centroid X
- Centroid Y
- Peak X
- Peak Y
- Radius

3.2.9.2.4 Radius Relative to:

The **Radius Relative to** control modifies the display of radius information. The radius is referenced from an **Origin** set up in the LBA-PC or from the continuously calculated **Average Centroid** position.

3.2.9.2.5 Strip Chart Zooming

All strip chart data is plotted on the same horizontal and vertical scale. This situation will cause traces that vary greatly along the vertical axes to dominate the vertical scale. Traces that have small vertical fluctuations will show up as flat lines. In order to see small details the user must stop or pause the data collection and drag a zooming box around the region of interest. To do this, start in the top left, drag a box spanning downward and to the right until the region of interest is selected. More than one zoom operation may be performed to achieve the desired detail.

Zooming out can only be done once. The plot will return to full zoomed-out mode. Zooming out is accomplished by dragging a box from the bottom right back to the top left. The size of the zoom-out box does not matter because all zoom out operations return the plot to the full view.

Note: The direction of the zoom operation (in or out) is controlled by the direction the box is drawn, down and to the right to zoom in and up and to the left to zoom out.

3.2.9.3 Peak/Centroid Scatter Plot and Histogram

There are two ways to use the Scatter Plots in the Beam Stability window. One is to test stability from the standpoint of spatial dimension using units such as millimeters or microns. The other is

to use it as it relates to pixel units on the detector array. If you choose to do pointing stability using spatial units such as mm or µm; the bins of the scatter/histogram plot and the horizontal and vertical grid lines **will not have any correlation** to the individual pixels on the detector. In other words, the bins in the histogram and the pixel grid of the detector will not have the same crosshatch granularity. On the other hand, if you do it from the pixel-units standpoint, the bins on the histogram **will correlate** with the size of the pixel grid on the detector. The drawback however, is that you will be forced to multiply the results by the pixel scale of the detector to get the data into real world units of distance.

The units on the horizontal and vertical axes of the scatter plots will change depending on how you setup LBA-PC. They could be microns, millimeters, and fractions of pixels or any of the units that are offered in LBA-PC. In short, the units on the X/Y-axes of the histogram/scatter plots are the same as the units selected in LBA-PC for quantitative results. You can select these units by going to LBA-PC's main menu and selecting:

Options > Camera > Pixel Units

If, for example, you desired to see which pixels on the camera most often contained the peak of your beam, setup your histogram bins to work in terms of individual camera pixels. To do this go to the main menu on LBA-PC and select:

Options > Camera

From the camera dialog you would select the camera that matched your detector and then select the **Pixel Units** to be **PX** (or pixel units). In the **Pixel Scale** spin control you would enter **1.0** to tell LBA-PC that your pixels are one pixel wide. Before closing the dialog you should make sure that the **Resolution** drop down box is set to **1X**. Resolutions other that **1X** may be used but this will be discussed later. In this example we will choose **1X** because we do not want to limit which pixels the peak might fall upon. Click **OK** to accept the changes to the camera dialog.

Now we will setup the origin in LBA-PC to match that of the histogram plot. On the main menu select:

Options > Beam Display

Set the **Origin Location** to **Window LL** to coincide with the Beam Stability plot convention. Setting the origin to values other that Window LL will work but the user should be aware that the beam window and histogram might be horizontally or vertically inverted with respect to one another.

Make sure that LBA-PC is collecting data and return to the Beam Stability window. Press the reset button to restart the histogram.

Note: Whenever units are changed in LBA-PC, the scatter plot should be reset because previously plotted samples will not be adjusted to reflect the new plot axis dimensions.

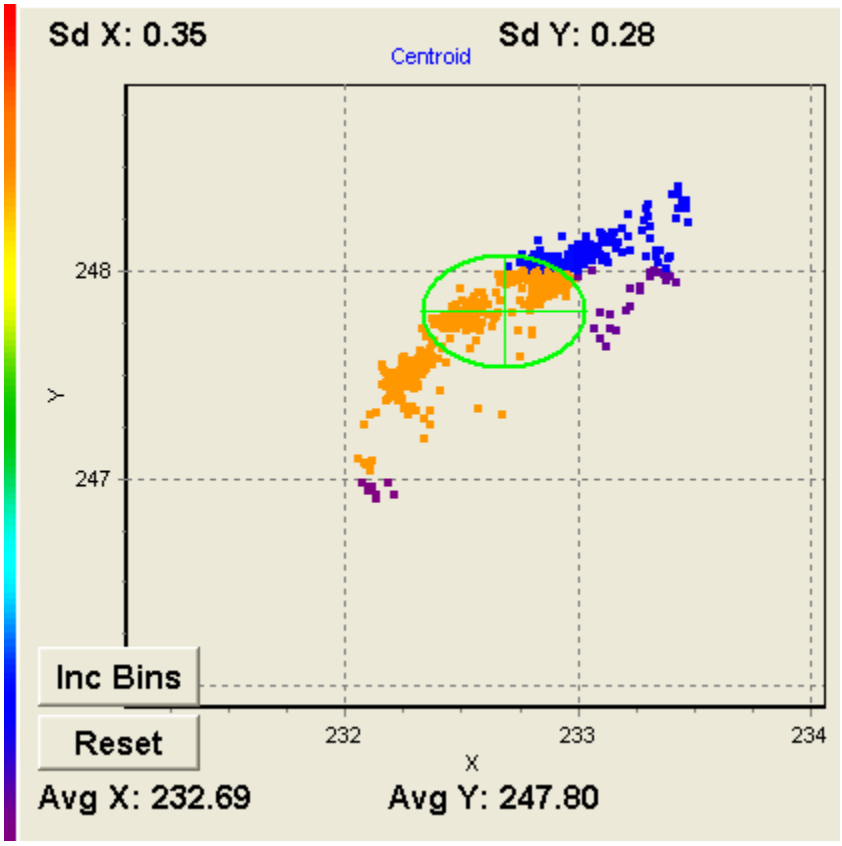


Figure 37

The Centroid and Peak Histogram windows now have horizontal and vertical plot scaling in units of pixel, with histogram bins the size of a single pixel. Note also that we have the same plot orientation as the LBA-PC beam window. In the Figure above we can see that most of the centroids are falling 232 pixels from the left and 247 pixels from the bottom (assuming that your origin is set to **Window LL**). In order to get this into real world units we would simply multiply the pixel units by the pixel scale of the camera. In the example above the pixel scale, read form the camera dialog was 13 microns per pixel. Thus the centoid would become roughly:

$$232.66(pixel) \bullet \left(13 \frac{\mu m}{pixel}\right) = 3024.58(\mu m)$$ From the left (X)

$$247.80(pixel) \bullet \left(13 \frac{\mu m}{pixel}\right) = 3221.4(\mu m)$$ From the bottom (Y)

The ellipses in the histogram windows have X and Y diameters two standard deviations wide and tall respectively.

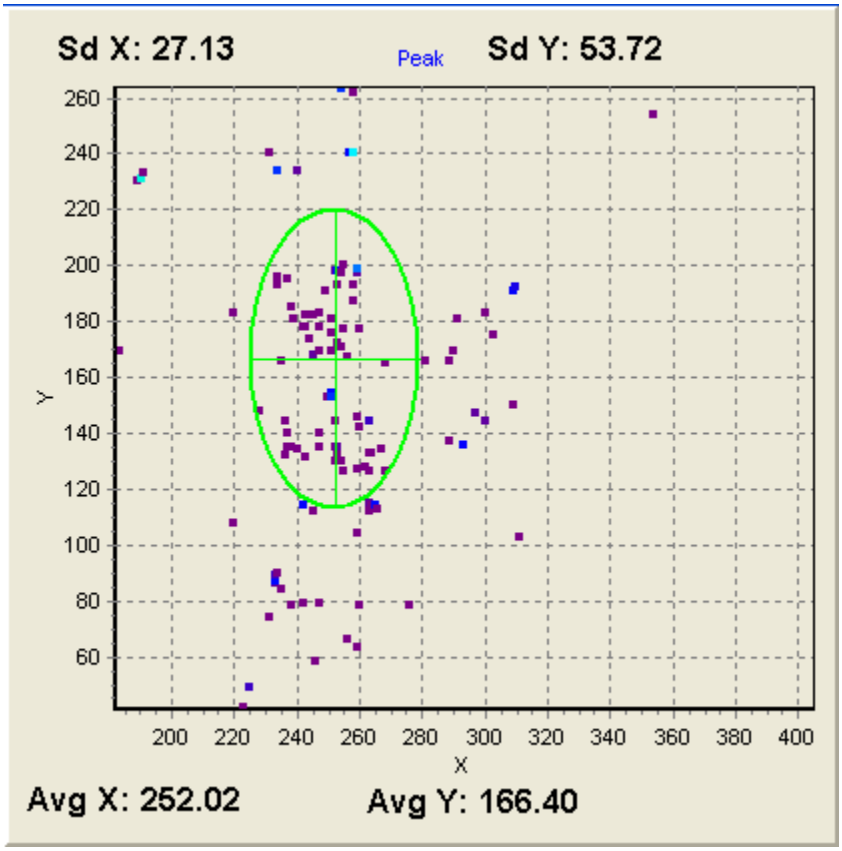


Figure 38

3.2.9.3.1 Zooming Histogram Plots

The zooming feature for histogram plots works basically the same as it does for the strip chart window. (See Strip Chart Zooming)

3.2.9.3.2 Capture Resolution Settings.

When setting capture resolutions to settings other than **Full** and **1X**, it is important to note that the peak location scatter plot will not have peak locations on any pixel location in the array. A 4X resolution for example, would have peaks occurring every forth pixel as a result the Peak Scatter plot would look like something like the following figure:

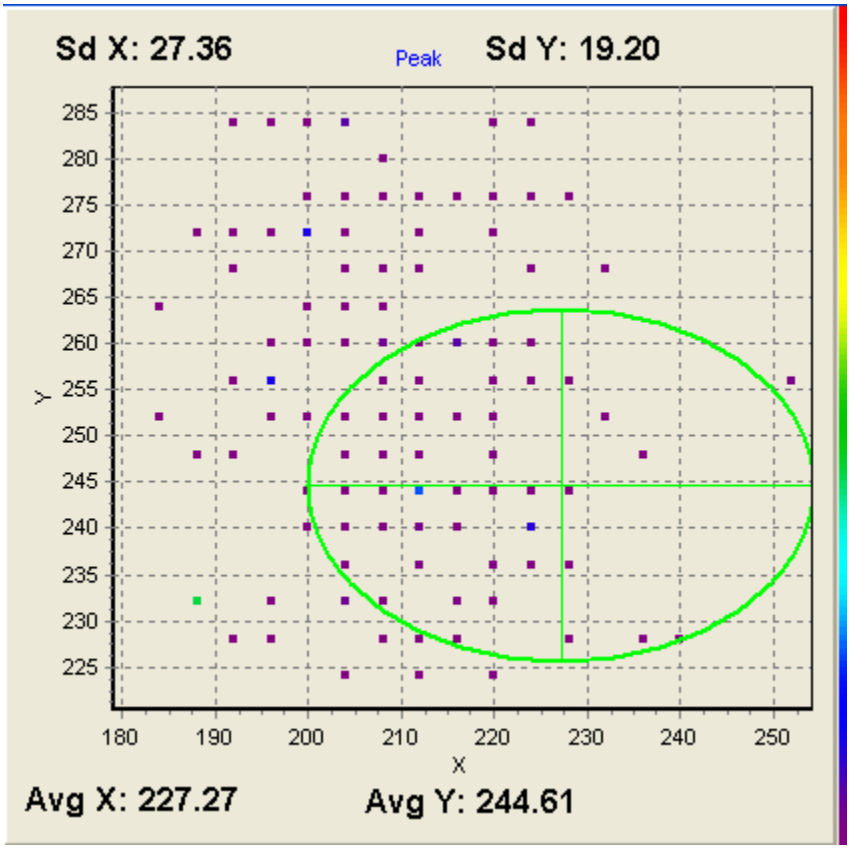


Figure 39

Note how peak locations seem to fall in a grid like pattern. This is to be expected when you are capturing every 4th pixel.

3.2.9.3.3 Real World Units

Setting LBA-PC's Quantitative results to real world units of length such as **µm** and **mm** may be accomplished by going to the main menu and choosing:

Option > Camera

Make the appropriate real world unit selection in the **Pixel Units** drop down box. This method of analyzing beam stability is in many ways similar to that discussed above however when viewing the scatter plots the user must understand that the X/Y-axes will be in whatever units are selected above. Also, the grid lines of the scatter plots will not have the same granularity as the pixel grid on the detector. This method is best when scientific units of length or beam centroid displacement are needed. When one understands the method explained above this method should be intuitive. Remember to reset the scatter plot whenever units are changed in LBA-PC.

3.2.9.3.4 Increment Bins and Reset

The centroid scatter-plot is also a histogram of the centroid location. The color bar between the Peak and Centroid plots provides the user insight about centroid location/frequency. Colors in the upper part of the bar indicate higher frequencies.

When running, the user will notice that blocks of data points have the same color. These blocks of color represent the binning of the histogram. The program, based on the range of data being presented, automatically defines the bin size.

If the user desires to decrease the size of the bins, simply click the **Inc Bins** button and the bins will be divided in half both vertically and horizontally creating 4 bins out of each existing bin. Bin size will be decreased when the program collects the next data point, and previously plotted points will be re-plotted with respect to the new bin size. If the Pointing Stability program is paused, the change will not take place until the program is started and the next data point is collected.

3.2.10 Create Palette...

Clicking on this option will cause a separate color palette generation application to be launched. This application will allow the user to design their own custom beam display color palette. Spiricon has included a sample set of palettes that you can use or alter as you wish.

Using this tool, the user can easily create their own palettes, or modify the standard palettes provided with Spiricon products.

The Spiricon Palette Generation program (c:\Spiricon\LBAPC\PALETTEGEN2.EXE) is shown below. This program is very easy to use once a few concepts are understood. This program can be launched independently via the Windows Start button, or from within the LBAPC application as follows: From the **Options** menu select **Create Palette...**, the following window will appear:

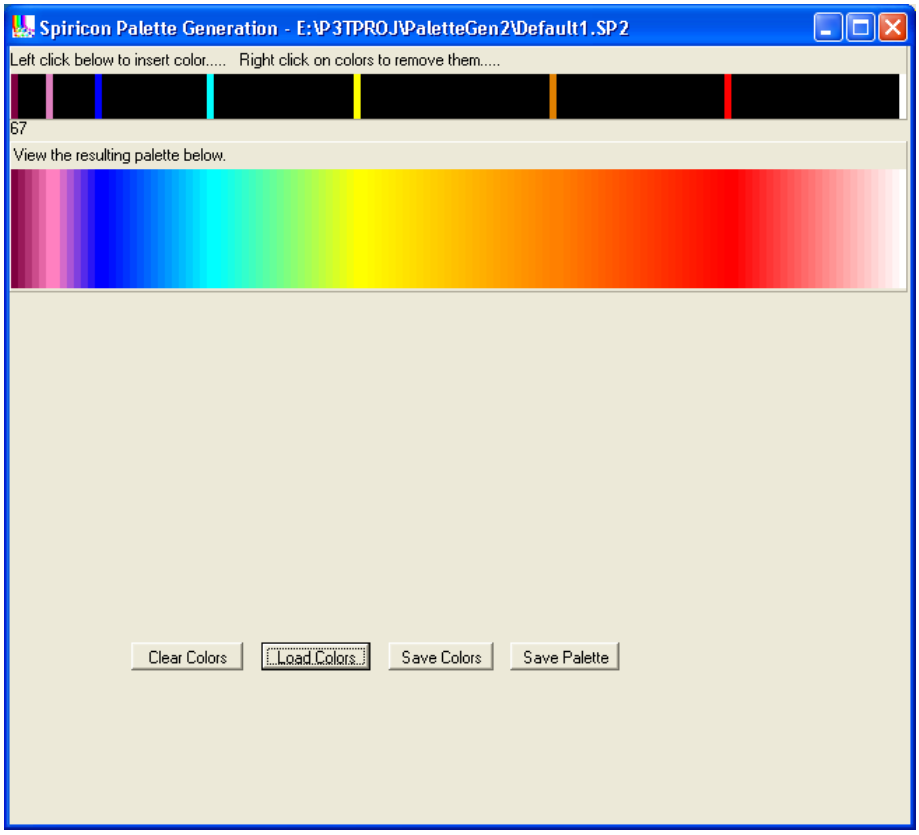

Spiricon Palette Generation - E:\P3TPROJ\PaletteGen2\Default1.SP2
Left click below to insert color..... Right click on colors to remove them.....
67
View the resulting palette below.
Clear Colors
Load Colors
Save Colors
Save Palette

Figure 40

Upon opening, the above two horizontal color bars will be black. The designer can create a new palette by placing seed colors into the upper bar and observing the resulting palette in the lower bar. Colors on the left represent low intensities while colors on the right represent high intensities. The upper bar contains entries for 128 individual colors, numbered from 0 on the left to 127 on the right. You must define at least 2 colors to create a palette, or as many as 128 if you want to choose the color of all possible displayed colors. LBA-PC uses a 128 color palette to describe all beam display images, As you slide the mouse pointer along the upper bar a number (just below the upper bar) will indicate which of the 128 color position is selected.

Left mouse clicking on a location in the upper bar will allow you to place a seed color at that physical location. A Color selection dialog box will appear as shown below:

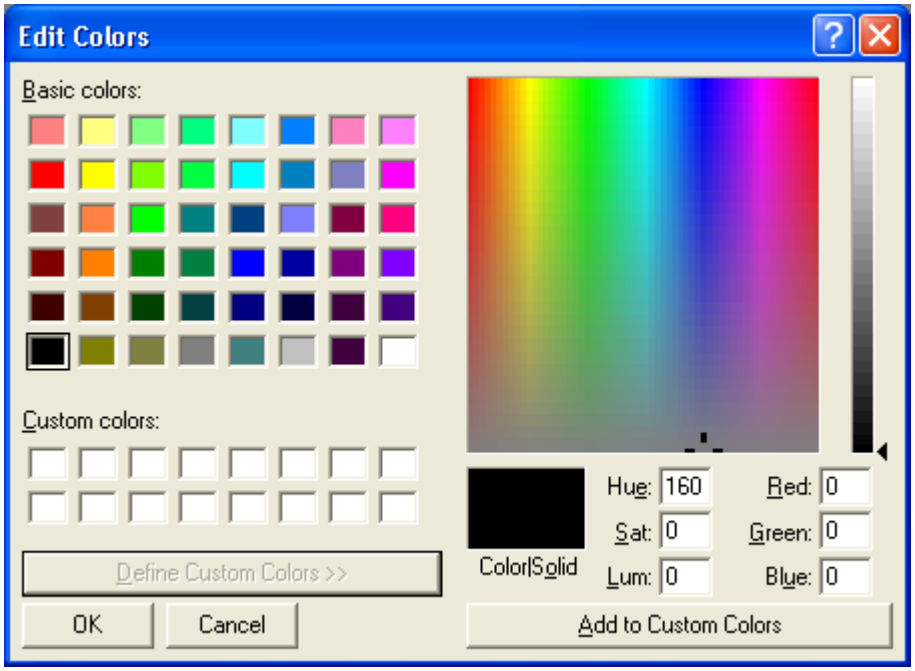


Figure 41

The user can either select one of the basic colors from the set on the left of the dialog, or create a custom color using the controls on the right. Clicking OK will place the selected color into the upper bar.

Continue to add seed colors until the displayed palette matches your desired effect.

To remove a seed color from the upper bar simply right-click on it.

3.2.10.1 Saving the Palette

Once you have the palette design looking the way you want it click the **Save Palette** button. Enter the file name that you want the palette to be known by and save it into your c:\Spiricon\LBAPC\Palette\ directory. The file extension **.pal** will automatically be applied.

3.2.10.2 Save Colors

The palette generation tools purpose is to create palettes of 128 entries, with minimal user input. Thus, the user may enter only 2 seed colors and the tool will interpolate the remaining colors. It is however difficult to move the other direction, that is to say, given a palette with 128 colors please reduce it to the original 2 seed colors. Therefore, a second file type was created to save the users seed colors for the purpose of editing later. This file type has a **.sp2** extension. The **Save Colors** button is for the purpose of saving **.sp2** file types or in other words, palettes that you can edit.

*Note: Palettes saved as **.pal** file types cannot be loaded into the Palette Generation Tool (PaletteGen2.exe) for editing!*

3.2.10.3 Load Colors

The **Load Colors** button is used to load the seed colors from **.sp2** files into the Palette Generation Tool for editing.

*Note: Users should save a **.sp2** file for each **.pal** file they desire to tweak at some later date.*

3.2.10.4 Clearing Colors

Removes all seed colors and resets the palette display.

3.2.11 Password Lockout

You can enter a **Password** that will cause all of the LBA-PC setup functions to become inaccessible. The password acts as a toggle. Type in the password once and all setup options will become disabled. Type it in a second time and setup capability will be restored.

The password has been factory set. To find out your password call the Spiricon Service Department at 435-753-3729 between the hours of 9:00 am and 5:00 pm MST. The password will only be given out to an authorized individual. An authorized individual is one whose name appears on the original Purchase Order, the person whose name appears on the completed warranty card, or to an individual who knows the Purchase Order Number used to make the purchase. It can also be obtained by a written request on your company letterhead, signed by an officer of the company.

3.3 Pass/Fail... Drop Down Menu Selections

3.3.1 Pass/Fail... enable and define its operation

All pass fail operations are enabled or disabled by checking the **Master Enable** box.

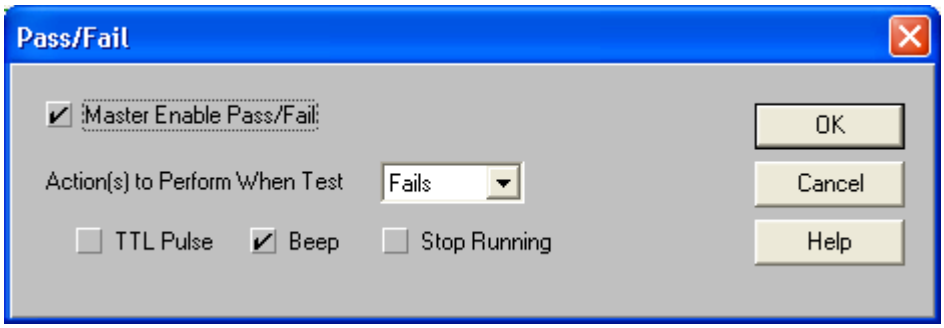


Figure 42

You can choose what **Action(s)** will be performed based upon if the results **Fails** or **Passes** the designated tests.

Check the appropriate box to obtain these available actions:

- **TTL Pulse**: If you want the LBA to send a TTL pulse out the rear J5 connector, pin 1, each time the Pass/Fail condition is met.
- **Beep**: If you want the LBA to cause your PC to Beep, each time the Pass/Fail condition is met.
- **Stop Running**: If you want the LBA to halt and display the frame that caused the Pass/Fail condition to be met.

3.3.1.1 PASS or FAIL results

The remaining Pass/Fail dialog boxes are used to set the **Pass/Fail limits** for the results items that you want to test and screen for. When you check an item, you turn on the Pass/Fail screening for that particular result. At the same time, you change how that result item will appear in the results window. If a results item is being tested and it **fails** the test limits, the displayed color will appear RED; if it **passes** the test limits, it will appear in GREEN.

3.3.1.2 Pass/Fail Units

The test units are always the same as what appears in the results window. If you redefine the results window units, the set Pass/Fail values will not automatically rescale to the new settings. In this case, you must manually change the Min. and Max. limits to meet the new unit requirements.

3.3.1.3 Pass/Fail dialog boxes

The remaining Pass/Fail dialog boxes are very similar in how they allow you to select and set limits for the result items that you want to test. In each instance you must:

1. Enable the results item by checking on its selection box.
2. Set the test limit values that are required.

In some instances you can select either or both **Minimum** and **Maximum** test limits.

*Pass/Fail testing can only be performed on **Current** frame results. No Pass/Fail testing is allowed for **Statistics** results.*

Pass/Fail testing can only be performed on computational results that are enabled in the Computations dialog box.

Most of the Pass/Fail dialog box edit control items are obvious in their meaning, and how to set them up. A few items are less obvious and are explained in the following sections.

3.3.2 Quantitative Pass/Fail

The following results may be set in the **Pass/Fail Quantitative...** dialog below the main menu **Pass/Fail** item.

3.3.2.1 Min Fluence

The **Min Fluence** test is performed on the **Min** value in the **Quantitative** results display. This test is best applied in conjunction with a manually **Drawn Aperture**. It can be used to test for a Minimum fluence range of values over a specified region of your beam.

If your beam is a Top Hat, don't use this test. Use the Top Hat Fluence setting in the Top Hat Pass/Fail dialog box.

3.3.2.2 Centroid

The **Centroid** Pass/Fail item allows you to define a circle that must contain the centroid of the beam energy. To implement this test you must define the location of the **center** of a circle in terms of its X and Y coordinate in the beam display window, and the **Radius** of the circle that must contain it.

Both the X and Y Centroid location results will change color from GREEN to RED should the centroid fall outside this circle.

3.3.3 Elliptical Pass/Fail

The following results may be set in the **Pass/Fail Elliptical...** dialog below the main menu **Pass/Fail** item.

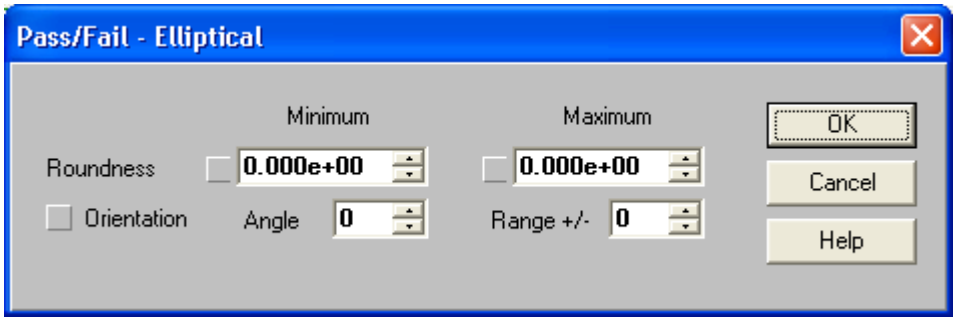


Figure 43

3.3.3.1 Orientation

The **Orientation** Pass/Fail item applies to the major axis inclination of an Elliptical beam. The units for these two edit controls are always in degrees. The Major axis can tilt through an angle in the range of +90 to -90 degrees. You can set the desired tilt Angle, and a +/- Range around this angle, that will meet your testing criteria. The **Rotation** result will change color from GREEN to RED should the angle fall outside of these set limits.

3.3.4 Gauss Pass/Fail

See the **Pass/Fail Gauss...** dialog below the main menu **Pass/Fail** item for a list of these items.

3.3.5 Top Hat Pass/Fail

See the **Pass/Fail Top Hat...** dialog below the main menu **Pass/Fail** item for a list of these items.

3.3.5.1 Top Hat Fluence

The Top Hat computational results displays a value for the **Max** and **Min** fluence observed in a Top Hat beam's energy profile. This result is affected by which Top Hat method is being employed. The **Top Hat Fluence** Pass/Fail edit control items are applied to both the **Max** and **Min** fluence results. It is anticipated that the **Minimum** Pass/Fail limit is primarily applicable to the **Min** results, and that the **Maximum** Pass/Fail limit is primarily applied to the **Max** results. Thus an energy intensity range can define the acceptable limits of the Top Hat beam's working surface area.

3.3.5.2 Divergence Pass/Fail

The following results may be monitored from the **Divergence...** dialog below the main menu **Pass/Fail** item.

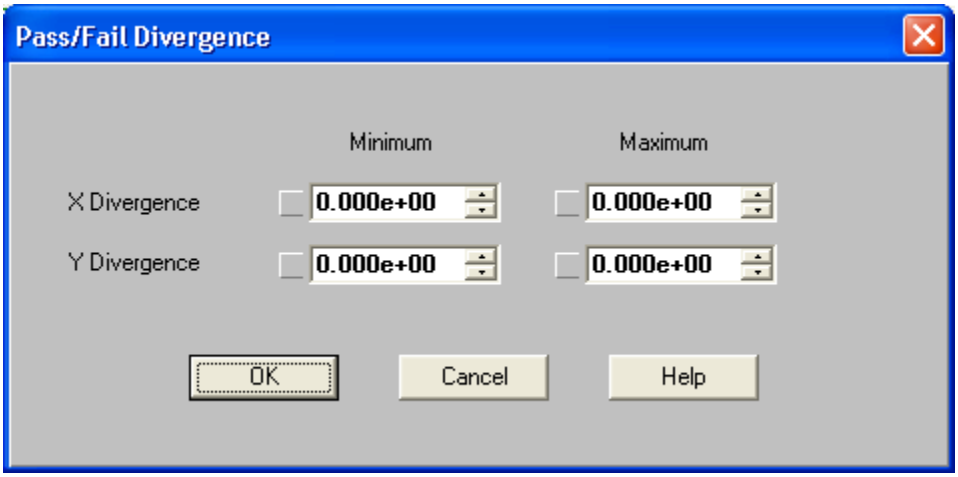


Figure 44

3.4 Window... Drop Down Menu Selections

Note: The numbers appearing in front of the selections will vary with the screen setup.

Tile

1 Results

2 <Frame> (Beam display window)

3 <W x H x R> (Pan/Zoom window)

4 <T:tt R:rr> (Tilt Rotate Window)

5 Histogram (Histogram display window)

Click on one of the numbered items to restore and activate the window.

3.4.1 Tile

Click on the **Tile** item to force all of the LBA-PC child Windows to return to their default sizes and locations.

3.5 Start!/Stop!... A Toggle Menu Action Item

Activating the **Start!** menu item will cause the LBA-PC to start collecting and processing frames of data. The source of the data frames can be either live video input to the Frame Grabber card, if installed, or from previously stored data files. Refer to the **Capture Method** section for source selection.

Activating the **Stop!** menu item will cause the LBA-PC to stop collecting and processing new data.

During Ultracal operations, the **Stop!** menu item can also be used to abort the calibration process. An abort will cause the last previously generated (if any) Ultracal conditions to be restored.

3.6 Ultracal! Menu Action Item

Ultracal™ is a trademark of Spiricon Inc.

Ultracal processing is protected under United States Patent Nos. 5,418,562 and 5,440,338.

Activating the **Ultracal!** menu item will cause the LBA-PC to begin an automatic camera calibration cycle. The results of this operation will be to store a calibration frame that will be used to preprocess all data frames newly acquired from the Frame Grabber card.

Note: The Ultracal process is only applied to newly acquired data frames; not to data that was acquired prior to an Ultracal execution; nor is it applied to data from a data file. If you execute a Post Processing operation, Ultracal will be turned OFF at the start of Post Processing, and remain OFF after it's completion.

The status of the Ultracal condition is visible in the Ultracal Enunciator shown here and at the bottom of the LBA-PC's main display screen.

If the color of the Ultracal Enunciator is:

GRAY, Ultracal processing is turned OFF.

GREEN, Ultracal operation was successful and is OPERATING.

RED, Ultracal processing has been DISABLED because something caused the calibration to become invalid.

Hint: Just because the Ultracal enunciator is GREEN it doesn't mean that all is well. Camera baselines drift with temperature and over time. Therefore it is a good practice to re-Ultracal! just prior to collecting important data.

3.6.1 How to Ultracal!

- Block your laser beam from the camera.
- Point and Click the **Ultracal!** menu item.
- After a few seconds.. observe that the Ultracal Enunciator turns GREEN.
- Unblock your laser beam from the camera.

3.6.2 What Disables Ultracal!

Ultracal will become DISABLED if certain data collection conditions, that were in effect when the Ultracal operation was executed, are no longer in effect. In all cases, these conditions are the result of an operators change to the spatial acquisition settings. The DISABLED condition will occur if you make changes to:

- The Hardware Zoom.
- The Hardware Pan location.
- The Camera Type or Resolution setting.
- The Camera Electronic Shutter setting.
- The Video Gain and/or Black Level settings.

3.7 AutoExposure!... Menu Action Item

This menu item is only enabled when certain types of cameras are connected. These cameras must be fitted with a remote controllable electronic shutter. From versions 4.XX, only analog cameras with remotely controlled shutters, such as: Pulnix TM-745, TM-765, TM-6, and TM-7, will be supported. In the future we intend to add additional camera types that feature electronically controlled exposure times, adjustable gain settings, and programmable electronic shutters.

*Note: This feature is only available when operating with the **Trigger Mode** set to **CW**. It is disabled in all Pulse modes.*

3.7.1 AutoExposure! Operation

When this menu item is enabled it indicates that your camera selection is set for a camera with some type of remotely controllable shutter or exposure timing and that your **Trigger Mode** is set to **CW**. If you click on this menu item the LBA-PC application will attempt to automatically set the camera shutter or exposure to a value appropriate for the amount of power incident upon your camera's focal plane array. The **AutoExposure** algorithm will start with the maximum exposure time and reduce the exposure until the peak fluence is less than 90% of the camera's dynamic range. If it reaches the shortest exposure time allowed by your camera and can not meet the above criteria, it will leave the exposure setting at this minimum value and request that you attenuate your laser using some external means. I.e., either place additional ND filters into the laser beam path or reduce the output power of your laser source. After attenuating your laser it may be a good idea to rerun the **AutoExposure** operation.

3.7.2 AutoExposure Interacts with Ultracal

With most any camera that has a programmable shutter or exposure, a change of the shutter/exposure setting will produce a change in the camera black level setting, and therefore may disable ultracal, which will cause the Ultracal indicator to turn red. It is therefore recommended that any changes to the AutoExposure are followed by an Ultracal operation.

*Notice: Some cameras suffer a reduced operating dynamic range when very short exposure times are employed. This can be seen as a dramatic change in the camera baseline or as a reduction in the camera's saturation level. If your camera reacts in one of these ways you may find that the **AutoExposure** technique will fail to yield optimum results.*

Chapter 4 DISPLAY WINDOWS

4.1 Main Window

You will probably want to run the LBA-PC application main window in its maximized display size. This will allow you to cram as much information as possible onto your display. We recommend that you operate in a minimum 1024x768 mode, larger if your graphics hardware and monitor will support it.

The Main Window is divided into 5 regions. They are laid out from top to bottom and are designated as:

1. Title Bar: Here you'll find the Product ID, the version level, and the copyright. Also the familiar maximize-minimize arrows and the close task button. The current configuration file name is also shown here.
2. Menu Bar: To gain access to the various operational and setup menus, click on the drop down items; File, Options, Pass/Fail, Window, and Help. To enable Ultracal! processing, an AutoExposure! cycle, or to Start! and Stop! data acquisition, click on these action menu items.
3. Toolbars: The number and types of toolbars that can appear is as many as three and as few as none. The number of toolbars is a user selectable option. The types of tools that they contain are partly programmable by the user.
4. Child Window area: This largest region is where the child windows of the LBA-PC application will appear. Three of these child windows can be resized, and all can be minimized. The possible child windows are:
    - The Beam Display window
    - The Results Display window
    - The Pan/Zoom Display window
    - The Tilt/Rotate Display window
    - The Histogram Display window
5. Status Bar: Indicates various status information regarding the above displays.
6. Beam Stability: The Beam Stability Window is not actually a part of the Main Window. When activated it launches a totally separate application window that can be manipulated independent from the Main LBA-PC application.

4.2 The Beam Display Window

You can view your laser beam profile in either a **2D** or **3D** display format. You can resize this window and minimize it. The top title bar in this child window will indicate the displayed <**Frame**> number.

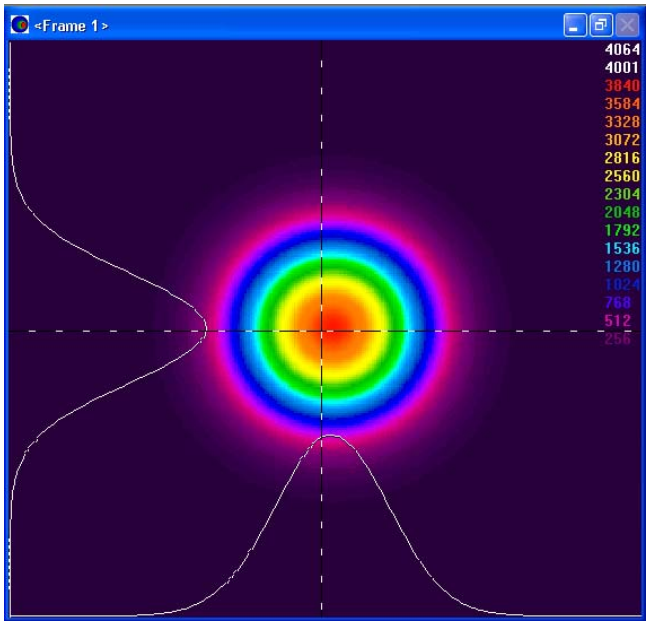


Figure 45

4.2.1 Frame Comment

The Frame Comment is a text string label that you can attach to a data frame. It can be saved with the data file, and it will print as a title if you choose to print the associated frame. You can replace the <Frame> number by double-clicking inside the Display Window's title bar. The Frame Comment dialog box (see below) will appear. Type your comment on the line provided, select how to apply the comment, and then click OK!

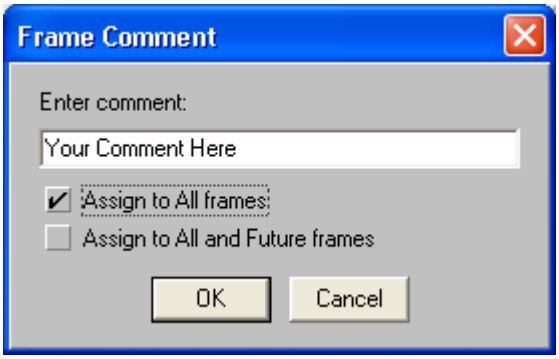


Figure 46

A Frame Comment can be applied in 3 different ways.

If neither of the check boxes in this dialog box are selected: The comment will only be associated with the currently displayed frame for as long as this particular frame remains in the frame buffer. When a new data frame overwrites this frame location, the comment will be lost, and once again the

<Frame> number will appear. Both the comment and the data frame can, however, be Write Protected.

If the **Assign to All frames** box is checked: This comment will be applied to all valid frames in the frame buffer.

- Empty frames will not be commented.
- New frames that are acquired will not be commented.
- Write Protected frames will be commented.

If the **Assign to All and Future frames** box is checked: This comment will be applied to all valid frames in the frame buffer, and to all frames that are newly acquired.

- Empty frames will not be commented.
- Write Protected frames will be commented.
- Comments will appear as shown below:

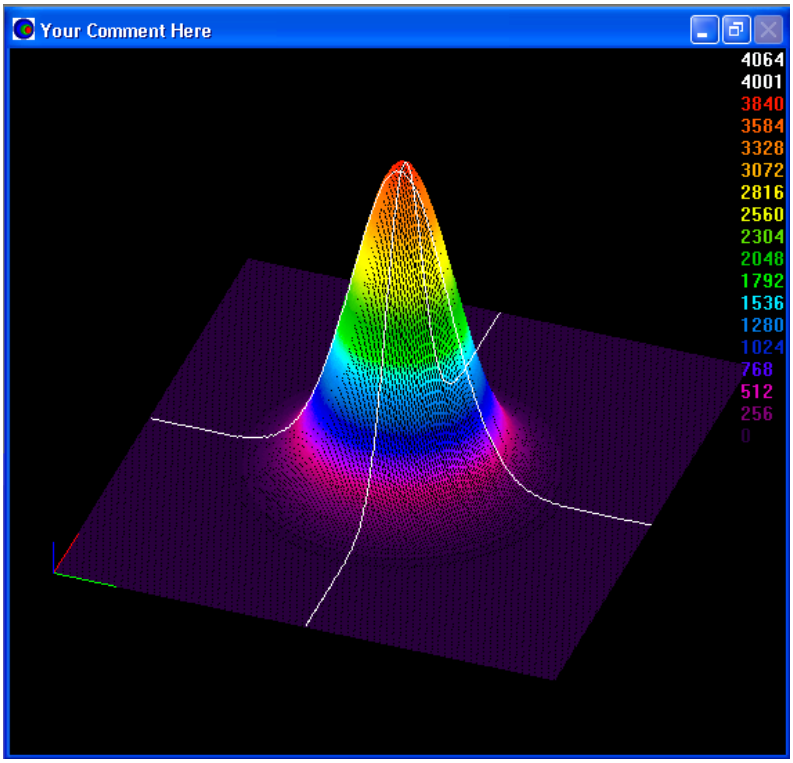


Figure 47

*Note: The comment line will say **Live Frame** if the **Capture Method** is set to **Live Video** mode. Comments assigned prior to entering **Live Video** mode will be restored when the **Live Video** mode is terminated.*

4.2.2 Shortcuts

In the Beam Window… Double left click to bring up the Beam Display dialog box.

4.3 The Results Display Window

This window will display the computed results based upon the selections enabled in the Computations dialog box. You can minimize, maximize, or resize this window. The top title bar in this child window will indicate the **Frame** number associated with the current result values. With **Statistics** results disabled, the **Results Window** will fit nicely along the left side of the child display area.

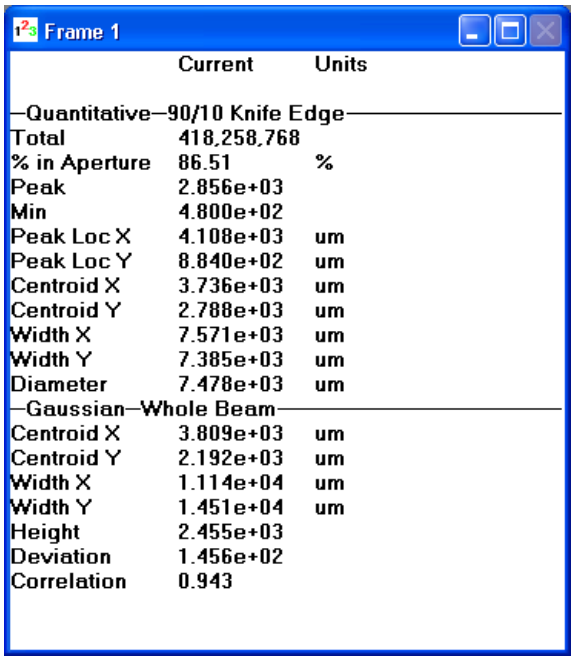
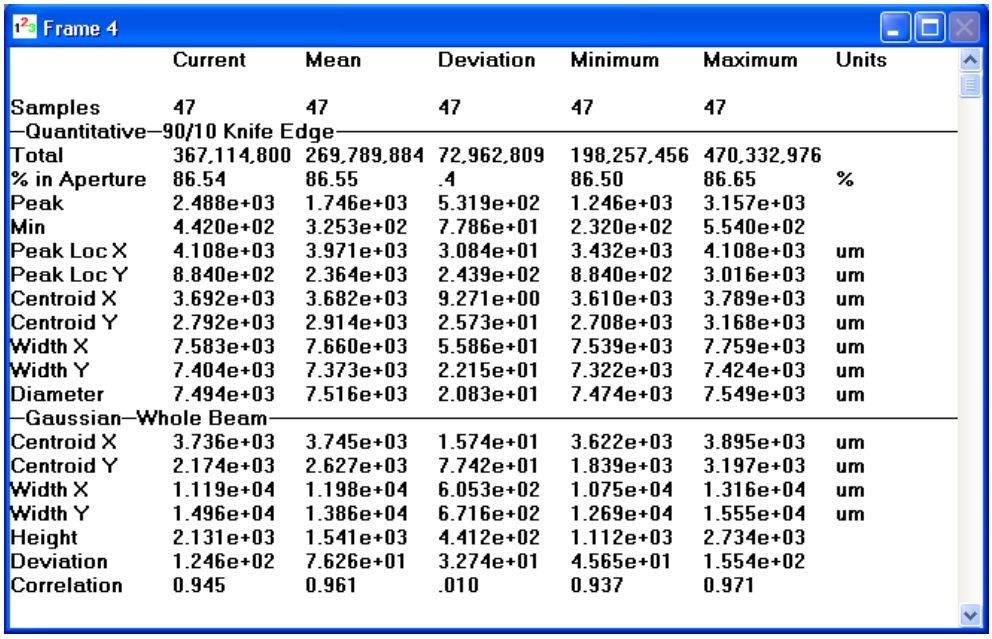


Figure 48

With **Statistics** enabled you will either need to use the horizontal scroll bar to bring the statistical results into view, or you will need to maximize and/or resize this window.



	Current	Mean	Deviation	Minimum	Maximum	Units
Samples	47	47	47	47	47	
—Quantitative—90/10 Knife Edge—						
Total	367,114,800	269,789,884	72,962,809	198,257,456	470,332,976	
% in Aperture	86.54	86.55	.4	86.50	86.65	%
Peak	2.488e+03	1.746e+03	5.319e+02	1.246e+03	3.157e+03	
Min	4.420e+02	3.253e+02	7.786e+01	2.320e+02	5.540e+02	
Peak Loc X	4.108e+03	3.971e+03	3.084e+01	3.432e+03	4.108e+03	um
Peak Loc Y	8.840e+02	2.364e+03	2.439e+02	8.840e+02	3.016e+03	um
Centroid X	3.692e+03	3.682e+03	9.271e+00	3.610e+03	3.789e+03	um
Centroid Y	2.792e+03	2.914e+03	2.573e+01	2.708e+03	3.168e+03	um
Width X	7.583e+03	7.660e+03	5.586e+01	7.539e+03	7.759e+03	um
Width Y	7.404e+03	7.373e+03	2.215e+01	7.322e+03	7.424e+03	um
Diameter	7.494e+03	7.516e+03	2.083e+01	7.474e+03	7.549e+03	um
—Gaussian—Whole Beam—						
Centroid X	3.736e+03	3.745e+03	1.574e+01	3.622e+03	3.895e+03	um
Centroid Y	2.174e+03	2.627e+03	7.742e+01	1.839e+03	3.197e+03	um
Width X	1.119e+04	1.198e+04	6.053e+02	1.075e+04	1.316e+04	um
Width Y	1.496e+04	1.386e+04	6.716e+02	1.269e+04	1.555e+04	um
Height	2.131e+03	1.541e+03	4.412e+02	1.112e+03	2.734e+03	
Deviation	1.246e+02	7.626e+01	3.274e+01	4.565e+01	1.554e+02	
Correlation	0.945	0.961	.010	0.937	0.971	

Figure 49

Hint: A short cut that will turn off the computed results is to minimize this window.

4.3.1 Shortcuts

In the Results Display Window… Double left click to bring up the **Computations** dialog box.

Right click to bring up a Shorthand Results selection pop-up window. This pop-up will allow you to enable or disable the individual results items, plus provides a quick way to Reset the Statistics results and also a method to save the current results to the Clipboard.

Figure 50

4.4 The Pan/Zoom Display Window

This window provides you with a graphical representation of where and how the digitized image relates to the detector on your camera, and the tools to modify those setting. The regions indicated in this display are not drawn to scale. This window can be minimized but not resized. In this window you can:

- Hardware Zoom-in and Zoom-out.
- Soft Zoom-in and Zoom-out.
- Pan the Window vertically and horizontally.

The **title bar** indicates the current image size that is being captured and stored into the frame buffer, and the current resolution setting. Because this window is kept as small as possible the image size text is often truncated. Move the mouse pointer into the title bar and a hints display will pop-up and show the full text.

The outer **White** area represents the photosensitive surface area of the camera's detector.

The **Red Dot** indicates the approximate placement of the X,Y origin. You can **not** change or affect the location of the origin in this window. To make changes, see the **Origin Location** edit control in the **Beam Display** dialog box.

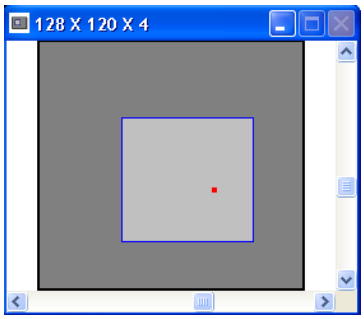


Figure 51

4.4.1 Hardware Zooming

The **Dark Gray** region depicts the **Capture window**, i.e., the region on the camera detector where the image is being acquired. Because this relates to how the frame grabber hardware is configured, it is referred to as the **Hardware Zoom box**. If you **Double-left-click** inside this box, you will cause this box to **Zoom-in** by a factor of 2x. If you Double-left-click outside this box you will **Zoom-out**. Observe that the image resolution will increase as you zoom-in; x4.., x2.., x1.., is in the increasing direction. As you zoom-in the image size will remain the same, until the resolution can no longer increase. At this point the image size will start to decrease, making the apparent size of the image larger.

The center of the Hardware Zooming action will be the intersection point of the Cursors. If the Cursors are turned Off, the zoom center will be about the center of the current frame. See also Zooming Constraints in Section 4.4.4.

4.4.1.1 Analog Camera Zooming

The chart below depicts the zooming process for an analog (non-digital) style camera. The starting point is based upon how you configured the image size and resolution in the Camera dialog box. First find your resolution factor in the top row. Then drop down to the display width size. In the example below the resolution is x8, and the width is 64. Each time you zoom in you'll be following the arrows leaving each location and leading to the next. In this example your zoom-in sequence will begin at 64x60x8, then progress to 64x60x4, 64x60x2, 64x60x1, 32x30x1, 16x15x1. You will retrace this route in reverse order as you zoom-out.

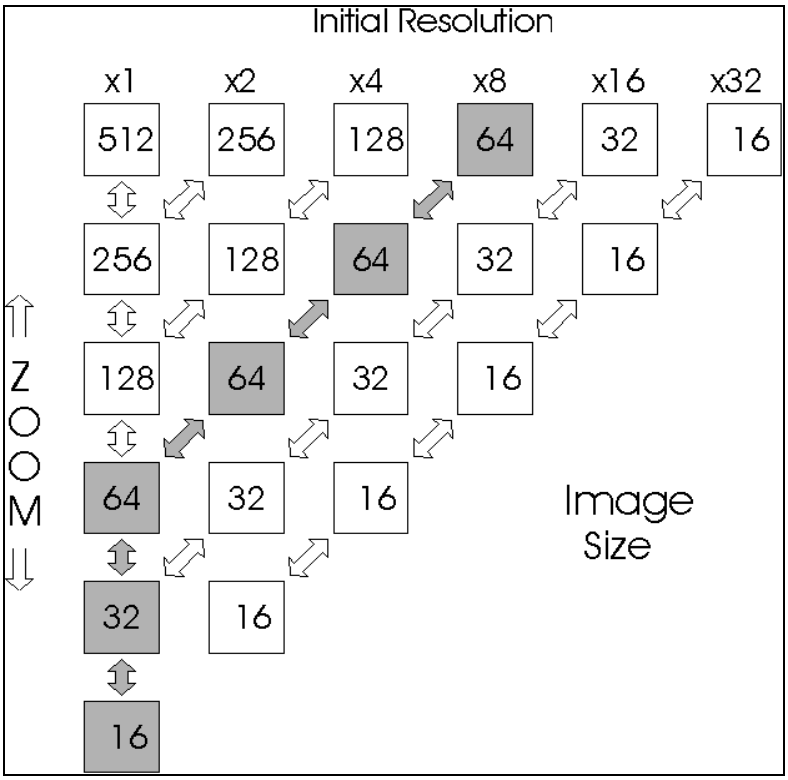


Figure 52

The above example works for all analog non-interlaced cameras, interlaced Interline transfer cameras, and interlaced Full-Frame transfer cameras.

If your camera is an interlaced Frame transfer type, the above example works in CW mode, but works slightly different in any of the Pulsed modes, i.e., Trigger Out, Video Trigger, and Trigger In. These style cameras will only output a pulsed laser image in one field. As a result the x1 resolution is denied, and the x2 resolution is the highest possible setting. Under this scenario, the above example will progress 64x60x8, then 64x60x4, 64x60x2, 32x30x2, 16x15x2.

With the release of version 4.00 a new Full 1x camera resolution has been made available. This resolution makes the hardware zooming operate for an analog camera the same as if it were a digital camera. See the next section to learn how digital camera zooming operates.

4.4.1.2 Digital Camera Zooming

Digital camera zoom image sizing does not follow the same powers-of-two rule that is shown above for analog cameras. For digital cameras both the **Full 1x** and the **1x** resolutions are the same size, and that size is set to the maximum imager dimensions that the Spiricon frame grabber can reliably capture. This can vary from camera to camera based upon the pixel clock rate and other image framing characteristics unique to each camera design.

Hardware zooming steps involve dividing the horizontal and vertical pixel counts by 2 and then rounding to the next even value when the results come out odd. This rule applies whenever the resolution is set to either **Full 1x** or **1x**. If the zooming begins at a resolution less than 1x, say 4x, zooming steps will first cause the resolution to increase from 4x to 2x to 1x, whereupon the first rule of dividing by 2 will then take over.

4.4.2 Soft Zooming

Soft Zooming, unlike the above **Hardware Zoom**, does not affect your data acquisition frame size or resolution. **Soft Zooming** only impacts the magnification of the displayed image. To initiate a Soft Zoom, **Double-right-click** inside the **Dark Gray** box. Observe that a smaller **Light Gray** box now appears, and that your beam display image has been magnified. You can continue to Soft Zoom-in by Double-right-clicking until your image is magnified to 16x15 pixels. To Soft Zoom-out, **Double-right-click** outside of the Light Gray box. Each soft zoom increases or decreases the image magnification by a factor of **2x**.

The center of the Soft Zooming action will be the intersection point of the Cursors. If the Cursors are turned Off, the zoom center will be about the center of the current frame.

Note: You can not perform Hardware Zoom operations once you have caused a Soft Zoom to occur. To change the Hardware Zoom you must first zoom all the way out of the soft zoom, until the Light Gray box is no longer visible.

4.4.3 Panning

You can Pan the **Dark Gray** capture window across the camera's active detector region. Panning works at all zoom and resolution settings that do not already contain the entire digitizable area of the camera's imager. If Soft zooming is activated, then the Panning controls will only pan the **Light Gray** zoom box.

Two scroll bars are provided to allow you to perform the panning operations. The **Horizontal** scroll bar will allow you to pan Left and Right; the **Vertical** allows you to pan Up and Down.

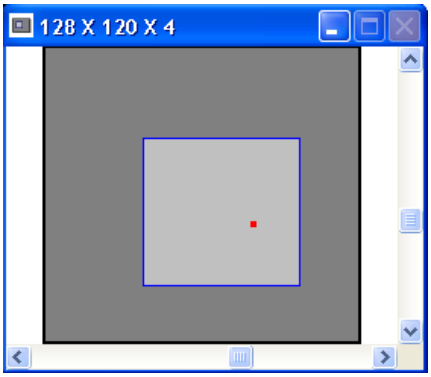


Figure 53

4.4.4 Zooming and Panning Constraints

The **Camera Resolution** that you have set in the Camera dialog box will constrain how your displayed image can be positioned by the Panning and Zooming controls.

For example: If you have set the Camera Resolution to 4x, then the image can only be positioned onto pixels whose locations are even multiples of 4, such as. . .0, 4, 8, 12, 16. . .128, . . .etc.

Likewise, when you zoom-out to an image that contains a lower resolution, you may have positioned the Cursors to select a zoom center point that is on a pixel that is not a multiple of your present Camera Resolution. In that case the image and cursors will snap to the nearest pixels that comply with the above constraints. Therefore, a point of interest may disappear when you zoom-out to a lower resolution.

4.5 The Tilt/Rotate Display Window

This child window is visible only when in the **3D** display mode. It provides you with graphical and numerical information of how your **3D** image is orientated in both **Tilt** and **Rotation**. This window can be minimized but not resized.

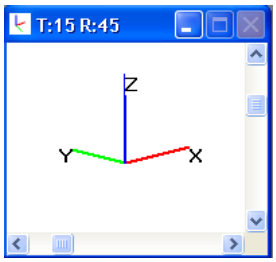


Figure 54

The XYZ corner markers allow you to orientate your image with respect to the **2D** display. This marker will represent either the **Upper Left** or **Lower Left** corner of the **2D** display depending upon how you have placed the Origin Location.

If the **Origin** is placed in the **Upper Left** of either the Window or Detector, then the XYZ marker will be in the **Upper Left** corner of the display.

If the **Origin** is placed in the **Lower Left** of either the Window or Detector, then the XYZ marker will be in the Lower **Left corner** of the display.

If the **Origin** is **Manual** placed, then the XYZ marker will be in the **Lower Left** corner of the display.

For more information see Origin Location in Chapter 3.

4.6 The Histogram Display Window

This **Histogram** display window is visible only when the Histogram check box is enabled in the Computations dialog box. This window can be minimized and resized.

This bar chart is a fluence **Histogram** of the currently displayed frame of data. Each bar in the display represents a fluence **Bucket**. Each **Bucket** describes a range of quantified fluence values. The minimum **Bucket Size** is based upon a single count of the 8/10/12/14/15 bit digitized output of the A to D converter or digital camera. The Bucket will be scaled if energy calibration is in use. See Histogram computations in Chapter 6.

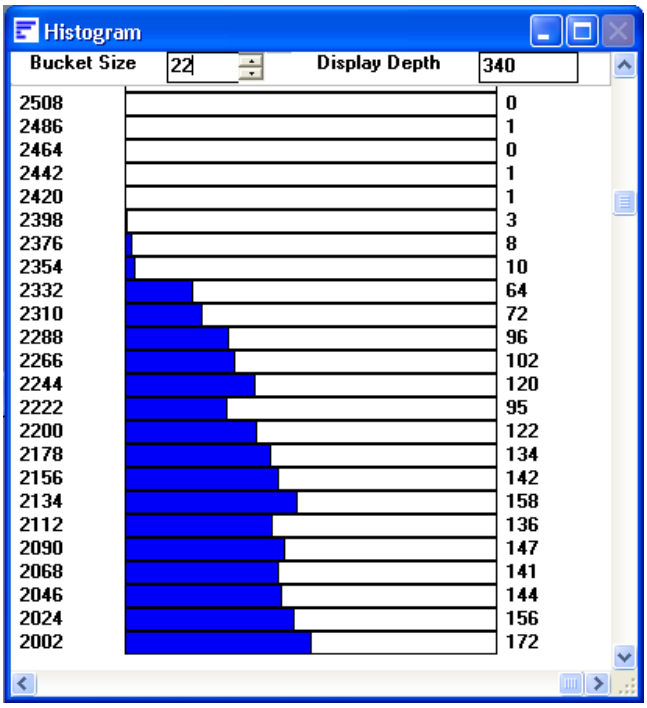


Figure 55

The numbers displayed along the left edge of the **Histogram**, indicate the lower value of each **Bucket**. You can set the **Bucket Size** by using the edit/spin control at the top of the Histogram display window or you can change it in the Computations dialog box.

The numbers along the right edge of the display are the total count of the number of pixels that have been placed into each of the Buckets. The length of the drawn bar graphs the depth to which the Bucket is filled. Zero count is on the left. The **Display Depth** indicator shows the current maximum value of the horizontal scale. The horizontal scale is auto-ranged to the current maximum count.

The horizontal scale can be magnified, so that smaller values can be enlarged for easy viewing. With the **Horizontal Scroll Bar** moved all the way to the right, the right edge of the bar display will represent the Bucket with the most number of pixels in it. By sliding this scroll bar to the left, the scale expands.

A **Vertical Scroll Bar** is also provided. This bar will allow you to bring into view Buckets that may extend higher than your display resolution will accommodate.

4.7 Shortcuts using the Mouse

A number of shortcuts are available that allow you to access some of the dialog boxes without going through the menu drop downs. These involve placing you mouse cursor into a region of a child window and then clicking either the right or left mouse button. These shortcuts methods are described below:

4.7.1 Shortcut to the Computations Dialog Box

- **Double-left-click** in the **Results** window.
- **OR, Single-right-click** to bring up a **Shorthand Results** selection pop-up window. This pop-up will allow you to enable or disable the individual results items, plus provides a quick way to **Reset** the Statistics results and also a method to save the current results to the Clipboard.

4.7.2 Shortcut to the Beam Display Dialog Box

- **Double-left-click** in the **Beam** window.

4.7.3 Shortcut to the Capture Toolbar Dialog Box

- **Double-left-click** in the Capture Toolbar.

4.7.4 Shortcut to the Capture Dialog Box

- **Double-right-click** in the Capture Toolbar.

4.7.5 Shortcut to the Beam Display Toolbar Dialog Box

- **Double-left-click** in the Display Toolbar.

4.7.6 Shortcut to the Beam Display Dialog Box

- **Double-right-click** in the Display Toolbar.

4.7.7 Shortcut to the Aperture Dialog Box

- **Double-right-click** in the Aperture Toolbar.

Chapter 5 TRIGGERING TYPES & CAPTURING METHODS

5.1 Triggering the LBA-PC

The LBA-PC can support four basic types of triggering:

- **CW** (or no trigger required), for lasers whose light output is continuous or pulsed at such a rate as to appear continuous to a camera (typically faster than 1000 Hz).
- **Trigger Out**, for lasers that can be pulsed by the LBA's trigger output.
- **Trigger In**, for lasers that can supply a trigger pulse to the LBA's trigger input.
- **Video Trigger**, for pulse lasers that cannot be either triggered by the LBA nor provide a trigger pulse to the LBA.

Note: Your degree of success with the various trigger modes will be linked closely to the type of camera you use.

Most cameras will operate well when observing **CW** laser beams. A linear (or predictable) response to light and good spatial uniformity are all that is usually needed for a camera to run successfully with the LBA-PC.

In **Trigger Out** mode, the timing of the arrival of the laser pulse is critical in successfully capturing all of the beam's energy. This is particularly true when employing **Line Scan**, **X/Y Scan** and **Tube** style cameras, which read out their images in a line-by-line and pixel-by-pixel destructive manner. **Frame** and **Interline** transfer cameras are less sensitive to pulse timing. The LBA-PC provides a **Trigger Out Delay** feature that positions the laser trigger pulse for **Frame** and **Interline** transfer camera operation.

The **Trigger In** mode is only appropriate with **Frame** and **Interline** transfer cameras. This mode will capture pulsed images with a high degree of success but may occasionally miss a pulse or distort the acquired image. The **Trigger In** mode will usually capture images with a hit rate better than 95%. The hit rate for **Interline** cameras is slightly better than for **Frame** transfer types. In general, this trigger mode has become less useful and is being replaced by the **Video Trigger** mode, see below.

The **Video Trigger** mode is only appropriate with **Frame** and **Interline** transfer cameras. It will have a hit rate of about 99% for short pulse lasers. This is the best possible solution when the LBA can not fire the laser using **Trigger Out** pulses.

Notice: Trigger In and Video Trigger modes will not work well with X/Y scanned, Line scanned (CID) and Tube cameras. These cameras employ destructive readout techniques. If your laser pulse occurs in the middle of the readout cycle, only half of the image will be captured.

5.1.1 A Note to Pulse Laser Users

The LBA-PC is designed to operate best when it can fire your laser. Most errors in timing and/or data acquisition are due to various camera quirks inherent in most commercially available cameras. Spiricon is constantly evaluating and testing new camera technologies and looking for the best cameras for a variety of applications. Contact Spiricon's Sales Department for the latest information regarding camera selection.

Since the perfect camera has not yet been found, we advise most LBA-PC users to operate pulsed lasers in **Trigger Out** mode whenever possible. Next best choice is the **Video Trigger** mode. These two modes will produce the most repeatable quantitative results.

5.1.2 Trigger Type CW

The setup for **CW** timing is the least complex of the setups. Therefore, we recommend that you use **CW** mode to verify that your camera is correctly installed and is operational. The basic **CW** installation requires that you set **Capture Method** to **Continuous**, and the **Capture Interval** to **1**.

5.1.2.1 Interlaced Cameras

In **CW** mode, interlaced cameras will support all available resolution settings and zooming capabilities. The highest of these resolutions will be made up of digitized data from both the odd and even fields. The odd and even data is assembled to form a single image. If you are observing a rapidly changing image at high resolution, you may observe line-to-line image breakup. Reduce your resolution to help stabilize the image. Some cameras may also exhibit an intensity variation from one field to the next. Most interlaced cameras will yield good high-resolution images in **CW** mode.

5.1.2.2 Non-interlaced Cameras

In **CW** mode, non-interlaced cameras will support all available resolution settings and zooming capabilities. Most cameras will yield good high-resolution images in **CW** mode.

5.1.3 Type Trigger Out

Two types of **Trigger Out** operations are provided. They are the runs **Always** and the only **While Running** choices. With the **While Running** selection, the triggering of the laser is switched on and off by clicking **Start!/Stop!**. If you choose the runs **Always** option, then the trigger output pulses will run continuously and independent of data collection.

5.1.3.1 Trigger Interval

The rate at which trigger output pulses occur is dependent upon the frame rate of the camera and the specified **Trigger Interval** value. Specifying an interval of 1 will cause the output trigger to run at the camera's frame rate (this corresponds to the fastest possible rate). A value of 2 will produce an output pulse on every second video frame. A 3 will pulse on every third frame, and so on.

Example: If you are using a 60 Hz frame rate camera and desire to produce an output pulse once each second, program a 60 into the Trigger Interval.

Should you need a high rep rate trigger, select a camera with as fast a frame rate as possible. (The frame rate of interlaced cameras is one half the field rate.) A Trigger Interval value of 1 will cause an output pulse to occur once per camera frame. Thus, an interlaced camera running at a

field rate of 60 Hz can cause a trigger pulse to output at a 30 Hz rate. A non-interlaced camera running at a frame rate of 60 Hz can produce a trigger output pulse at a 60 Hz rate.

5.1.3.2 Trigger Delay

The LBA-PC will produce trigger output pulses at the programmed frame **Interval** rate. With the **Trigger Delay** check box deselected, the trigger output pulses will occur at vertical sync time. With the **Trigger Delay** check box selected, the trigger output pulses will occur in the middle of the frame of a non-interlaced camera; or in the middle of field 2 of an interlaced camera. The reason to delay the trigger pulse is discussed in the following sections.

5.1.3.3 CCD Frame Transfer Camera, Interlaced

These camera types can only capture a laser pulse in one field. Therefore 2x is the highest resolution possible with pulsed lasers. The video output from each laser pulse will occur during the field outputting immediately after the laser trigger arrives. Since the laser is not synchronized with the camera, this means that the pulse can occur in either field. As a result you will observe a field hopping effect in the displayed image.

5.1.3.4 CCD Interline and Full Frame Transfer Camera, Interlaced

These camera types can capture a laser pulse in both fields at the same time. Therefore 1x high-resolution images are possible with pulsed lasers. The video output from each laser pulse will occur during the next two fields outputting immediately after the laser trigger arrives.

When the LBA is running, each digitized pixel is being tested for the trigger level pixel value. When a trigger field is detected, the data is retained in the frame buffer and displayed. The timing delay to the next frame that can be acquired depends upon the overhead needed to process the first frame.

As in earlier examples, the **Interline** camera can display a pulse acquired in both fields while the **Frame** transfer camera can only use one field. Because of the asynchronous arrival of the laser pulse the **Frame** transfer image will randomly hop fields.

5.1.3.5 CMOS Camera, Interlaced

Most CMOS cameras employ either line or X/Y scanning methods. As a result they are poorly suited for operation with pulsed lasers. Leave the **Trigger Delay** box disabled for all of these camera types.

5.1.3.6 Tube Camera, Interlaced

With pulsed lasers these camera types will yield an image in both the odd and even fields. Therefore 1x high resolution is possible. Leave the **Trigger Delay** box disabled for all of these camera types.

Note many tube style cameras will suffer image degradation in the second field, during the readout of the first. Tube cameras also suffer from long lag times, which make them poor devices for any, but the slowest rep rate pulsed lasers.

5.1.3.7 CCD Frame and Interline Transfer Cameras, Non-interlaced (Progressive scan)

These camera types can produce 1x high-resolution images. The video output from each laser pulse will occur during the next frame outputting immediately after the laser trigger arrives.

5.1.3.8 CMOS, CID Line Transfer and Tube Cameras, Non-Interlaced (Progressive scan)

These camera types can produce 1x high-resolution images. Leave the **Trigger Delay** box disabled for all of these camera types.

5.1.4 Type Trigger In

The **Trigger In** mode will not operate correctly with **X/Y Scan**, **Line Scan** , and **Tube** cameras. These include CID style cameras and almost all CMOS cameras. Use only **CCD Frame** and **Interline** transfer style cameras. In the following discussions, it is assumed that the laser is fired simultaneous with the arrival of the trigger pulse.

5.1.4.1 CCD Frame Transfer Camera, Interlaced

These camera types can only capture a laser pulse in one field. Therefore 2x is the highest resolution possible with pulsed lasers. The video output from each laser pulse will occur during the field outputting immediately after the laser trigger arrives. Since the laser is not synchronized with the camera, this means that the pulse can occur in either field. As a result you will observe a field hopping effect in the displayed image.

5.1.4.2 CCD Interline and Full Frame Transfer Camera, Interlaced

These camera types can capture a laser pulse in both fields at the same time. Therefore 1x high resolution images are possible with pulsed lasers. The video output from each laser pulse will occur during the next two fields outputting immediately after the laser trigger arrives.

5.1.4.3 CCD Frame and Interline Transfer Cameras, Non-Interlaced (Progressive scan)

These camera types can produce 1x high resolution images. The video output from each laser pulse will occur during the next frame outputting immediately after the laser trigger arrives.

5.1.5 Type Video Trigger

The **Video Trigger** mode is designed to be used with lasers that cannot be externally triggered, nor can they provide an external trigger output to the LBA. Since this mode is so easy to use and requires no connection between the laser and the LBA, it has become the method of choice for almost all pulsed laser applications.

When you select the **Video Trigger** mode a **Video Trigger Level** menu item will become active. You must program the **Video Trigger Level** to the raw pixel threshold value that will be used to detect the presence of the laser pulse. The choices are shown in counts and represent 1/16, 1/8, ¼

and ½ the maximum possible counts based on the number of A to D conversion bits. For example: If you are using an LBA-712PC frame grabber (a 12 bit digitizer) you have the following possible **Video Trigger Level** choices: 256, 512, 1024, 2048. If you set the level to 512, the LBA will capture a laser beam pulse as soon as it detects a pixel raw energy value of 512 or greater.

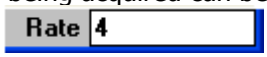
Unless your camera is very noisy we recommend that you use the minimum level as a starting value.

5.1.5.1 CCD Frame and Interline Transfer Cameras, Interlaced

When the LBA is running, each digitized pixel is being tested for the trigger level pixel value. When a trigger field is detected, the data is retained in the frame buffer and displayed. The timing delay to the next frame that can be acquired depends upon the overhead needed to process the first frame.

As in earlier examples, the **Interline** camera can display a pulse acquired in both fields while the **Frame** transfer camera can only use one field. Because of the asynchronous arrival of the laser pulse, the **Frame** transfer image will randomly hop fields.

5.2 Capture Methods and Rate Control

The rate at which data is being acquired can be seen in the **Rate** counter displayed at the far right edge of the status line. 

To determine the acquisition rate in frames per second, divide the camera's frame rate by the indicated **Rate** counter value.

In every case, the fastest rate at which data can be acquired is ultimately dependent upon how you have configured the LBA to operate. Rates slower than the fastest rate can, to a greater extent, be controlled by the user. The fastest acquisition rates are thus determined by a combination of factors that are dependent upon the selections made in the **Capture**, **Computations**, and **Display** dialog boxes. In general, the more features you are using, the slower things will operate.

Two specific edit control items are provided that allow you to program the acquisition rate. These are the **Capture Interval**, and **Trigger Interval**.

Frame **Averaging** and **Summing** will also figure into the rate calculations. For example, if you are averaging 8 frames, then the acquisition time will increase by the amount of time that it takes to acquire and average 8 frames of data.

The following examples are assuming that no frame **Averaging** or **Summing** is taking place, and that all other overhead operations occur faster that the resulting acquisition rates.

5.2.1 Programming the Capture Interval

In **Continuous**, **Block**, and **Live Video** Capture Methods, the Capture **Interval** value will determine the data acquisition rate. With the **Single Shot** Method, this value becomes a delay count that determines the number of frames that will elapse from the time you click **Start!**, until a single frame is acquired. The capture interval interacts with the Trigger **Type** and Trigger **Interval** settings in the following ways:

5.2.1.1 With Trigger Type set to CW

The frame rate of the camera and the **Capture Interval** will determine the capture rate.

*Example: With the **Capture Interval** set to 10, and a 30 Hz frame rate camera, the capture rate will be 3 fps.*

5.2.1.2 With Trigger Type set to Trigger Out

The frame rate of the camera and the Trigger and Capture Intervals will combine to determine the capture rate.

*Example: With the **Capture Interval** set to 10, and the **Trigger Interval** set to 5, the captures will occur once for each 50 frames. If your camera has a 25 Hz frame rate, the capture rate will be once every 2 seconds, or 1/2 Hz.*

5.2.1.3 Trigger Type set to Video Trigger with the LBA firing the laser

The frame rate of the camera and the Trigger and Capture Intervals will combine to determine the capture rate.

*Example: If the LBA is being used to trigger the laser, and the **Capture Interval** is set to 10, with the **Trigger Interval** set to 10, the captures will occur once for each 100 frames. If your camera has a 25 Hz frame rate, the capture rate will be once every 4 seconds, or 1/4 Hz.*

In the above example, only frames that satisfy the **Video Trigger Level** threshold value will be counted. Thus if some of the laser shots are too low in energy, the resulting acquisition rate will lengthen in multiples of the **Trigger Interval**.

5.2.1.4 Trigger Type set to Video Trigger without the LBA firing the laser

The frame rate of the camera and the laser pulse rate will combine to determine the capture rate. Only frames that satisfy the **Video Trigger Level** threshold value will be counted. Thus if some of the laser pulses are too low in energy, those shots will not be included in the Capture Interval count, resulting in slower acquisition rates.

*Example: If the LBA is **not** being used to trigger the laser, and the **Capture Interval** is set to 10, the captures will occur once for each 10 times that the laser fires. If the laser fires at a 2 Hz rate, then the capture rate will be once every 5 seconds, or 1/5 Hz.*

5.3 Integration Control

If you have purchased the digital camera option then multiple frame integration can be performed when using certain select digital cameras. This feature is not usually required for laser beam analysis because most lasers are much too bright when compared to camera sensitivity. However outputs from some fiber optic systems and laser diodes at certain wavelengths can be hard to detect at normal integration times. To overcome this problem we have added a camera integration control. This feature is limited to Digital cameras that maintain frame, line and pixel clock signals during the non-readout periods. These cameras further constrain the integration times to multiples of the normal frame integration period. Furthermore, these cameras provide a TTL input signal that allows the LBA frame grabber to control the integration timing.

Note: Do not confuse this type of integration control with features on high-end digital cameras that have externally programmable integration controls. These later types of cameras are programmed by issuing serial commands to the camera's internal microprocessor. See section 5.4 for a discussion of these types of cameras.

5.3.1 Integration Operation

The Integration control is found in the **Options**, **Capture**, dialog box. If you purchased a digital camera from Spiricon that is compatible with external integration capabilities, then the **Integration** edit control will become operational when the matching camera type has been selected. The Spiricon supplied camera power cable will have the integration circuits prewired into the cable.

The only thing required to enable multiple frame integration is to set the **Integration** value to a number greater than 1. This number represents the number of frame periods that the camera will use for each frame of output video.

5.4 Digital Camera Operations

The largest growing segment of the camera market involves a rapid increase in the numbers and types of digital cameras available for both commercial and scientific uses. As a result, most of our recent efforts in camera testing and evaluating have involved digital cameras. Most all RS-422 and RS-644 (LVDS) digital cameras can be interfaced to any of Spiricon's new LBA-7XXPC-D (digital option) frame grabbers. The only major limitation has to do with the size of the image that can be captured. This limitation is impacted by the throughput of the frame grabber and the pixel clock and video frame format of the camera. In most cases this impact is limited to a reduction in the frame size or frame resolution that can be reliably acquired from the camera. The Spiricon supplied camera configuration files will take these limitations into account and will adjust the image size or resolution to insure stable operation.

The following section will discuss some of the operating features often seen in modern digital cameras and how those features may or may not be used with the LBA-PC software.

5.4.1 Digital Camera Control

Digital cameras often have a large number of control features. The number and methods for controlling these features varies greatly from one manufacturer to another. The basic control methods fall into two categories. The oldest control method employs switches and dials located on the outside and inside of the camera. More modern designs employ micro-processors inside the camera that can control the operations via serial commands issued from your PC's serial port. The manufactures of these cameras usually provide a camera control console application that must be run on your PC. A few manufactures require you to write your own control application. Some cameras have simple command protocols and can be controlled by typing commands into a simple terminal emulator program like Windows Hyper Terminal.Most digital cameras will power up in a default mode of operation. Some can have the default mode changed by the user. Others will always start operating in one mode and the user must change it to the desired configuration every time power is restored. The LBA-PC camera files are very specific to how certain of these features are configured. The camera file name will often include a reference to a critical feature. Most often these critical settings concern the image format of the camera.

5.4.1.1 Digital Camera Binning Effects

Many digital cameras support electronic pixel binning. This feature is usually used to increase the frame rate of the camera by decreasing the total number of pixels in the image. If a camera

operates in a binning mode compatible with the LBA application then we will often supply multiple camera configuration files, one for each bin format. Camera binning can occur in two different styles.

When the pixels are binned equally in both the horizontal and vertical direction, the resulting image maintains its aspect ratio and is best for operating in the LBA-PC application. This type of binning is labeled, 2x2, 3x3, 4x4, etc… Camera files for this type of configuration will usually say "BIN2X2" or "BIN4x4" somewhere in the file name. You must chose the configuration file that matches your camera binning or you will not be able to acquire a correct image.

When the pixels are binned unequally in the horizontal and vertical directions the resulting image will appear to have a distorted aspect ratio. We do not recommend operation of the LBA-PC under these conditions and so no camera files are provided to support this type of camera setting.

5.4.1.2 Digital Camera ROI Formating

Some digital cameras have a feature that allows then to readout only a defined Region Of Interest (ROI) of the focal plane array. This will reduce the data and increase the frame rate of the cameras operation. While this feature can be used with the LBA application, it is not an easy adjustment to make. If you must have a camera configuration designed to operate with some ROI requirement then you must make appropriate changes in the **Advanced**… **Special Camera Settings** dialog box. We recommend that you contact the Spiricon service department for assistance in making these changes.

5.4.1.3 Digital Camera Exposure Controls

Many digital cameras have user programmable exposure controls. These can range from very short integration times (microseconds) to very long integration times of many seconds. The exact nature and operation of these features can vary dramatically from one camera manufacturer to another. In general most of these capabilities are fully compatible with the LBA application without special considerations. Our suggestion is to try it and see how it works. With very long integration times some cameras will stop outputting frame syncs to the frame grabber. When this occurs the Video sync enunciator may turn RED. Under this condition this signal can be ignored.

Warning: Some cameras do not maintain good linearity of response when very short integration times are used. If you suspect this type of distortion then you should run a response test to determine if the problem lies with the camera. The only solution to this is to either avoid the short exposure times or employ gamma correction to try and compensate for the errors.

Besides programmable exposure control some cameras can have their exposure times controlled by externally applied digital signals. Some of these camera are compatible with Spiricon's Integration control feature discussed in section 5.3.

5.4.1.4 Digital Camera Triggering

Digital cameras can have a number of external triggering capabilities. Most of these have been found to be compatible with the LBA application. We suggest you test these features to determine if they achieve the desired results. If you are triggering a camera with a period longer than a frame time then some cameras will stop outputting frame syncs to the frame grabber. If

this period exceeds 3 seconds then the Video sync enunciator may turn RED. Under this condition this signal can be ignored. The next frame should be captured when the next trigger pulse triggers the camera.

5.4.1.5 Digital Camera Gain and Black Level Control

Most digital cameras have programmable gain and black levels. These settings often have default values that are not optimum for laser beam analysis. Usually the gain is too high and the black level is too low. The gain is set high because most camera makers want to achieve good picture taking sensitivity. The black level is set low to increase dynamic range.

For laser analysis the best gain setting is the lowest value that just allows the digital output to reach all ones, but before the camera imager goes non-linear.

The black level should be set just high enough to insure the absence of any zero pixels when the imager is dark.

Be sure to allow a little headroom on both of these settings because they will drift as the camera warms up.

Chapter 6 COMPUTATIONS

6.1 Computational Accuracy

Once you have mastered the skill of acquiring your laser beam's profile on the screen of the LBA-PC, your next thoughts will usually be directed toward the accuracy of the quantitative results.

The degree of accuracy of the computed results will be based primarily upon two factors. The first, and most significant, is the correct nulling of the background energy. The second has to do with optimizing the presentation of the beam display.

The background energy nulling operation establishes the zero reference from which all computed results are based. Failure to correctly null and periodically monitor the background energy will yield inconsistent results. Excessive background energy levels will yield oversized beam diameters and reduced magnitudes when energy relationships are compared.

The opposite effects will result if the background levels are excessively suppressed.

The LBA-PC is equipped with an auto calibration feature called **Ultracal™**. Ultracal will perform a nulling operation that is significantly more accurate than that which can be manually achieved. The Ultracal algorithm will also compensate for background noise and for camera shading.

The Ultracal™ processing feature is protected under

United States Patent Nos. 5,418,562 and 5,440,338.

Notice: We recommend that you allow both the camera and the LBA to warm up and reach thermal equilibrium before performing calibrations. One hour is usually sufficient as a warm-up period (at least two hours if your camera is a tube type). If the ambient air temperature is changing, then you might want to periodically recheck the background energy levels to make sure they haven't been significantly altered.

6.2 Numerical Formats

The LBA-PC uses an 8, 10, 12 or 14 bit A to D converter to digitize incoming video. Each video frame is then processed and placed into a block of memory called a frame buffer. During processing the LBA converts all pixel intensities to a signed 16 bit fixed point value. Processing can consist of, Ultracal baseline correction, Reference Subtraction, Gain Correction, Gamma Correction, Frame Summing, Frame Averaging and Convolution. The 16-bit format is used for all processing except frame averaging and frame summing. Frame averaging and summing uses a 32-bit format during the summing operation, but returns a 16-bit result after the division.

This 16-bit format is the basis upon which all computational results are performed, and all data files are created.

6.3 Beam Presentation Affects Results

Effective beam presentation is essentially an attempt to improve accuracy by increasing the signal-to-noise property of the digitized data. Since the camera and the digitizing process primarily fix the noise level, most of our efforts will concentrate on increasing the signal content.

Always try to optimize your beam's amplitude into the camera's dynamic operating range. Whenever possible, use external optical attenuation or a camera with electronic shutters to bring the beam's peak signal levels into the upper half of the video signal's dynamic range. If optical attenuation leaves you with low signal amplitude, you can use the LBA's video gain control to restore some of the loss.

Note: Increasing gain also increases noise, so use it sparingly. Changing the gain setting also affects the Black Level, so set the gain level first, and then use Ultracal! to readjust the Black Level and calibrate to the new noise conditions.

Always use the highest possible hardware zoom magnification level that will contain all of the beam's energy.

If your beam intensity is low and/or covers only a small fraction of the display window, use an aperture to eliminate the background energy noise in the wings.

Use external optical magnification if your beam begins to approach only a few pixels in width. It takes at least 10 pixels to get a reasonably good beam width measurement.

6.4 Manual Background Energy Nulling

Manual Background Energy Nulling is NOT recommended. Use the **Ultracal!** calibration feature instead.

Do not place any confidence in the computed results until you have nulled the background energy levels using **Ultracal!**.

The LBA-PC provides three different methods to assist you in removal of unwanted background energy from the quantitative calculations. They are:

- **Ultracal!** processing.
- A **Drawn Aperture** that can be drawn around the energy of interest, isolating the beam and effectively forcing all the energy outside the aperture to zero.
- An **Auto Aperture** feature that will draw an optimally sized aperture around your beam energy.

6.4.1 What is Ultracal!

The Ultracal processing feature should be used instead of manual energy nulling techniques. Ultracal employs a sophisticated proprietary algorithm that will yield greatly improved accuracy over various operating conditions and signal dynamic range. In addition, it can quickly be rerun if changes in setups are required as experimental conditions are modified.

Before executing **Ultracal!** be sure to optimize your beam presentation. This is essential as the Ultracal cycle will be specific to the current Pan/Zoom and Video Gain settings. You may also place a manually drawn aperture at this time, or later if you wish. The aperture is not locked by the calibration cycle and may be manipulated by the operator at any time.

The **Ultracal!** cycle can be run at any time, either in 2D or 3D mode. You must have the laser beam blocked from the camera detector. After completion of the **Ultracal!** cycle, the results will be accurate as long as the setup conditions remain the same, and your camera black level, shading and noise conditions do not change. Since most cameras tend to be a little drifty, we recommend that you

Ultracal! every 10 to 15 minutes, or whenever you think your camera may have strayed. This drift can be observed as changes in the background noise image. Un-illuminated areas will appear as gray and dark violet (almost black) random noise. If the background starts to look too gray then the baseline is drifting negative. If too dark, then the baseline is drifting positive. Note: These colors apply to the Continuous 128 color palette. They change depending upon the palette selection.

6.5 Clip Level

What is the Clip Level and how is it used?

The clip level is a processed *energy* pixel value. Only those pixel values that exceed the clip level are used in computing the following results:

- Beam Widths, if **Percent of Energy** or **Peak** methods are selected.
- Centroid Location.
- Elliptical beam Orientation.
- Top Hat: Mean, Standard Deviation, Min and Max, when in **Data** mode only.
- Effective Area.

Depending upon the **Beam Width Method**, the clip level value is determined as follows:

- With the **4-Sigma** and **Knife-Edge** methods and with the **Top Hat** results **disabled**, the LBA totals the pixel *energy* values in descending order until it finds the pixel which causes the sum to exceed 86.5% of the total *energy* value. The raw *energy* value of this pixel becomes the clip level.
- With the **4-Sigma** and **Knife-Edge** methods and with the **Top Hat** results **enabled**, the LBA sets the clip level to the value that is equal to **80**% of the current peak *energy* value.
- With the **Percent of Energy** method, the LBA totals the pixel energy values in descending order until it finds the pixel which causes the sum to exceed the set **Clip**% of the total *energy* value. The *energy* value of this pixel becomes the clip level.
- With the **Percent of Peak** method, the LBA sets the clip level to the value that is equal to the set **Clip**% of the current peak *energy* value.

The number of pixels with values above the clip level establishes the **Effective Area** of the beam. The locations of the pixels with values above the clip level are used to determine the beam's **Centroid Location** and **Elliptical beam Orientation**.

Note: When using a Knife Edge method, the Clip% value relates only to the Knife Edge measurement process, and not to the above Clip Level description.

6.6 Total Energy

The cameras used with the LBA-PC are not calibrated to directly provide *energy* of a laser beam. The **Energy of Beam** dialog box edit control lets you calibrate the LBA-PC to the *energy* of your laser. You must measure the *energy* of your beam using an external measuring device, then enter the *energy* here. The value entered must be the total *energy* of the beam for the frame currently displayed. For accurate results, the beam must fit inside of the current Pan/Zoom window.

If you enter a calibrated value of zero, the Total, Peak, Gauss Height(s), and Top Hat results are displayed as processed digitizer values. Any entry other than zero will immediately appear as the **Total**

energy results. The Units entry will determine the energy units that will appear behind the various *energy* displays, i.e., Peak mw/cm², etc.

If you are using a **Drawn Aperture** (without an Auto Aperture), then the **Total Energy** is the amount of *energy* inside the **Drawn Aperture**.

If you are using an **Auto Aperture** (with or without a Drawn Aperture), then the **Total Energy** is the amount of *energy* inside the **Auto Aperture**. Thus...

An Auto Aperture takes precedent over a Drawn Aperture.

6.7 Percent in Aperture

If you place a **Drawn Aperture** onto the beam display, the percentage of the total *energy* of the frame that lies inside of the **Drawn Aperture** will be computed.

If an **Auto Aperture** is present, then the value will represent the total energy contained within the **Auto Aperture**.

If no aperture is present, then this result will show 100%.

Auto Aperture takes precedent over a Drawn Aperture.

6.8 Peak and Min

These are the **Peak** and **Minimum** *energy* density values in the displayed frame, or within the **Drawn** or **Auto Aperture** if present. The **Minimum** value will most often be negative, and is therefore not meaningful except as an indication of the amount of noise present in the video signal.

Auto Aperture takes precedent over a Drawn Aperture.

6.9 Peak Location

This is the first location where the peak intensity value was found. The **Peak Location** is found by scanning the pixel data from left to right, and top to bottom. If a **Drawn** or **Auto Aperture** is present, then the scanning is confined to the pixels inside the aperture.

Auto Aperture takes precedent over a Drawn Aperture.

6.10 Centroid Location

The Centroid location is found by calculating the center of mass of all the pixels that satisfy the following clip level criteria, based upon the chosen **Beam Width Method**.

- In the case of **Percent of Peak**, the included pixels are those that are greater than the **Clip**% level.
- With **Percent of Energy**, the included pixels are those that are greater than or equal to the **Clip**% level.
- If the **4 Sigma** or one of the **Knife Edge** methods are chosen and the **Top Hat** calculations are not checked, the clip level is set to 86.5% of energy. If the **Top Hat** calculations are checked, then an 80% of Peak clip level is set.

The following equations describe the X and Y centroid locations from the collection of data points that satisfy the above energy clip level criteria.

$$x\ \ centroid = \frac{\sum (X \times z)}{\sum z}$$

$$y\ \ centroid = \frac{\sum (Y \times z)}{\sum z}$$

Where:
X = x locations of selected pixels.
Y = y locations of selected pixels.
z = value of selected pixels.

6.11 Beam Widths and Diameters

To some extent, beam width is a term that describes how you have decided to measure the size of your laser beam. The LBA-PC is designed to give you a set of measurement tools that will allow you to make this measurement as you see fit. During the past few years there has been some movement toward a consensus regarding a standard definition of beam width. This definition has grown out of laser beam propagation theory and is called the Second Moment, or D-4-Sigma beam width. (The D erroneously stands for Diameter.) Sigma refers to the common notation for standard deviation. Thus an X-axis beam Width is defined as 4 times the standard deviation of the spatial distribution of the beam's intensity profile evaluated in the X transverse direction. Taken in the Y transverse direction will yield the Y-axis beam Width.

Note: For a TEM_{00} (Gaussian) beam, 2-Sigma is the $1/e^2$ radius about the centroid.

The term **Diameter** implies that the beam is radially symmetric or circular in shape. The term **Width** implies that the beam is non-radially symmetric, but is however axially symmetric and characterized by two principal axes orthogonal to each other. Beams that are asymmetric, distorted, or irregularly shaped will fail to give significantly meaningful or repeatable beam width results using any of the standard methods.

6.11.1 D4-Sigma Method

From laser beam propagation theory, the **Second Moment** or **4-Sigma** beam width definition is found to be of fundamental significance. It is defined as 4 times the standard deviation of the energy distribution evaluated separately in the X and Y transverse directions over the beam intensity profile.

$$d_{\sigma x} = 4 \cdot \sigma_x$$

$$d_{\sigma y} = 4 \cdot \sigma_y$$

Where:

d_σ = The 4-Sigma beam width

σ = The standard deviation of the beam intensity

The standard deviations are derived from the variances of the energy distributions and are equal to the standard deviations squared. The variances are:

$$\sigma_x^2 = \frac{\sum_x \sum_y (x - \bar{x})^2 \cdot Z(x,y)}{\sum_x \sum_y Z(x,y)}$$

$$\sigma_y^2 = \frac{\sum_x \sum_y (y - \bar{y})^2 \cdot Z(x,y)}{\sum_x \sum_y Z(x,y)}$$

Where:

Z = the intensity of the pixel

$\bar{x}$ and $\bar{y}$ are the coordinates of the centroid

Only beam propagation factors based on beam widths and divergence angles derived from the second moments of the energy density distribution function, will allow one to predict how a beam will propagate. Other definitions of the beam widths and divergence angles may be used, but they must be shown to be equivalent to the second moment definitions for computing the correct beam propagation.

To make an accurate measurement of the beam widths with the LBA-PC you must aperture the beam inside a Drawn or Auto Aperture. The aperture must be approximately 2x the size of the beam. The Auto Aperture feature of the LBA-PC will automatically provide such an aperture under most operating conditions. It can be used in combination with a Drawn Aperture if needed. If your beam size is already equal to about 1/2 the beam display window, then you can usually get by without drawing an aperture, just be sure to center the beam in the window.

6.11.2 Knife Edge Method

Beam widths are computed using special algorithms that simulate knife-edge techniques. The method employed in the LBA-PC borrows from two sources. They are:

ISO 11146 Lasers and laser-related equipment—Test methods for laser beam parameters— Beam Widths, divergence angle and beam propagation factor

Note this document is being revised and split into three parts:

- 11146-1, Part 1: Stigmatic and simple astigmatic beams
- 11146-2, Part 2: General astigmatic beams
- 11146-3, Part 3: Alternative test methods and geometrical laser beam classification and propagation

And from the IEEE Journal of Quantum Electronics, Vol 27, No 4, April 1991 Choice of Clip Levels for Beam Width Measurements Using Knife-Edge Techniques by Siegman, Sasnett and Johnston.

The LBA offers the operator two methods for computing Knife Edge beam widths. The **90/10** method presets the Clip% values to **90**% and **10**% respectively, and the **Multiplier** to **1.561**. These are the recommended values based upon the above Siegman, et al. paper, and are very compatible with CCD camera noise figures. These values are perfectly correct for computing an

equivalent second moment width for TEM_{00} beams, and are a good approximation for many beams of mixed modes.

The second Knife Edge selection will allow you to program your own **Clip**% and **Multiplier** values. This option will allow you to set up for beams requiring special settings, which could get you into all kinds of trouble, since you can set these values to just about anything you like.

When the LBA's **Elliptical** results are disabled, the computed beam widths will be aligned with a pair of simulated knife-edges cutting one in each of the X and Y directions. Hence, the displayed beam widths will be indicated in the results window as X and Y. If your laser beam is not radially symmetric but does contain two axes of symmetry, you should rotate the beam such that the beam's axes align with the X and Y axes of the display.

When the LBA's **Elliptical** results are enabled, the computed beam widths will be aligned with a pair of simulated knife-edges cutting one in each of the Major and Minor axial directions. Hence, the displayed beam widths will be indicated in the results window as Major and Minor. The implication is that the displayed values represent the major and minor widths of an elliptically shaped laser beam.

6.11.3 Percent of Energy Method

The LBA measures the lengths of two orthogonal lines that pass through the beam centroid. The beam widths are determined by separately looking out along each line and count all the pixels that are greater than the set clip level. The reported beam widths are the number of pixels greater than the clip level multiplied by the pixel pitch.

When the LBA's **Elliptical** results are disabled, the computed beam widths are the measure of the pixels in the row and column that pass through the centroid. The beam widths in the results window are labeled X and Y.

When the LBA's **Elliptical** results are enabled, the computed beam widths are the measure of the pixels along the Major and Minor axes that pass through the centroid. The beam widths in the results window are labeled **Major** and **Minor**.

6.11.4 Percent of Peak Method

The LBA measures the lengths of two orthogonal lines that pass through the beam centroid. The beam widths are determined by separately looking out along each line and counting all the pixels that are greater than the set clip level. The reported beam widths are the number of pixels greater than the clip level multiplied by the pixel pitch.

When the LBA's **Elliptical** results are disabled, the computed beam widths are the measure of the pixels in the row and column that pass through the centroid. The beam widths in the results window are labeled X and Y.

When the LBA's **Elliptical** results are enabled, the computed beam widths are the measure of the pixels along the Major and Minor axes that pass through the centroid. The beam widths in the results window are labeled **Major** and **Minor**.

6.12 Elliptical beam

The LBA-PC can compute and display the **Orientation** of an Elliptical or rectangular beam and a coefficient of **Roundness**. The criteria for computing the Elliptical beam's **Major** and **Minor** beam widths are described in the Beam Widths and Diameters section.

The **Orientation** of an Elliptical beam is determined from the clip level. A smaller percent of peak or larger percent of energy will include more pixels, in the orientation calculation. A larger percent of peak or smaller percent of energy will include fewer pixels. Depending upon your laser beam this setting can have serious implications.

The **Orientation** is defined as the angle formed between the **Major** axis and the horizontal, pointing to the right. If the **Major** axis points above the horizontal, the angle is positive (+); below, the horizontal is negative (-). The **Major** and **Minor** axes are perpendicular to each other.

The **Roundness** result is the ratio of the computed beam widths. The **Minor** (smaller) beam width is always divided by the **Major** (larger) to produce a result less than or equal to one. Thus, beams with **Roundness** values close to 1.000 are nearly circular.

To view the shape of the computed ellipse, select **Options**, **Aperture…**, go to **Display Beam Width** and select **Ellipse**.

6.13 Gauss Fit

The LBA-PC can perform a least squares bivariate normal equation (Gaussian equation) fit using all of the data when doing a **Whole** beam fit. Or it can perform two univariate normal equation fits using orthogonal **Lines** of data through the Centroid Location.

With the **Elliptical** results disabled, the Gaussian fitter may be set to Disabled, **Whole Beam**, or **X/Y** aligned.

With the **Elliptical** results enabled, the choices are Disabled, **Whole Beam**, or **Major/Minor** aligned.

The Gauss Fit results are displayed as follows:

Whole Beam fits	**Line fits are X/Y or Major/Minor aligned**	
Centroid X,Y	Centroid X or Major*	Centroid Y or Minor*
Width X,Y	Width X or Major	Width Y or Minor
Height	Height X or Major	Height Y or Minor
Deviation	Deviation X or Major	Deviation Y or Minor
Correlation	Correlation X or Major	Correlation Y or Minor

The **Centroid Major** value is the distance from the fitted **Major** axis centroid to the origin axis, which is most perpendicular to the **Major** axis. The **Centroid Minor** value is the distance from the fitted **Minor** axis centroid to the origin axis, which is most perpendicular to the **Minor** axis. At 45° the **Centroid Major** value is the distance to the X-axis and the **Centroid Minor** is the distance to the Y-axis.

Whole beam fits are always X and Y aligned.

Line fits can be either **X/Y** aligned where the fits will be performed upon the data in the X & Y directions passing through the Centroid. Or the fits can be **Major/Minor** axes aligned with the fits performed upon the data on the Major and Minor axes passing through the Centroid.

All fits are least square fits, meaning that the algorithm minimizes the sum of the square of the differences between the data and the fitted surface or line, as described in the following equation.

$$A_{\min} = \sum_x \sum_y \left(Z_{xy} - S_{xy}\right)^2$$

Where:
Z_{xy} = Amplitude of the pixel data at (x,y).
S_{xy} = Amplitude of fitted surface at (x,y).

6.14 Whole Beam fit equations

The bivariate normal equation is used to fit data in two locked directions, X and Y. The **Whole Beam** selection assumes the beam is round or elongated parallel to the horizontal or vertical axis. The definition of the bivariate normal equation and the displayed results are as follows:

$$J = J_o e^{-2\left[\left(\frac{x-\bar{x}}{w_x/2}\right)^2 + \left(\frac{y-\bar{y}}{w_y/2}\right)^2\right]}$$

Where:

J	=	Amplitude at the point (x,y).
J_O *	=	Amplitude at the Gaussian center.
x	=	x location of pixel.
$\bar{x}$ *	=	x location of the Gaussian center.
w_X *	=	Horizontal width at 1/e² of energy.
y	=	y location of pixel.
$\bar{y}$ *	=	y location of the Gaussian center.
w_Y *	=	Vertical width at 1/e² of energy.

Parameters marked with an asterisk (*) are the variables fitted.

6.15 X/Y or Major/Minor line fit equations

The univariate normal equation is used to fit data in one direction. The definition of the equation and the displayed results are shown below:

for the X or Major axis

$$J = J_M e^{-2\left(\frac{M-\overline{M}}{w_M/2}\right)^2}$$

Where:

J	=	Amplitude at the point M.
J_M *	=	Amplitude at the Gaussian center.
M	=	Location of pixel.
$\overline{M}$	=	location of the Gaussian center.
w_M *	=	Width at 1/e² of energy.

for the Y or Minor axis

$$J = J_m e^{-2\left(\frac{m-\overline{m}}{w_m/2}\right)^2}$$

Where:

J	=	Amplitude at the point m.
J_m*	=	Amplitude at the Gaussian center.
m	=	Location of pixel.
$\overline{m}$	=	M location of the Gaussian center.
w_m*	=	Width at 1/e² of energy.

Parameters marked with an asterisk (*) are variables fitted.

$\overline{M}$ & $\overline{m}$ are not the same as the displayed Centroid Major and Centroid Minor results. However, they are used to compute those results items.

*Note: There is some display limitations when using the **Line Gaussian Fit** results. If you have set your Reference Source to either **Last Gauss** or **Auto Gauss**, no full frame Gaussian beams will be available to be placed into the **Reference** frame buffer. Thus any Beam Display selections that involve the **Reference** frame will not be updated nor display any images based upon the **Line** fit results. Use only **Whole Beam** fits if you want to use them in conjunction with the various **Beam Display** options.*

6.16 Deviation of Fit

The **Deviation** of fit result is a measure of the standard deviation of the beam intensity data from the fitted Gaussian surface or line. As this result approaches zero the data more nearly matches the Gaussian surface.

The definition of the Deviation is:

$$\sigma = \sqrt{\frac{\sum (Z-s)^2}{n-2}}$$

Where:

σ	=	Standard deviation.
Z	=	Pixel intensity.
s	=	Gaussian surface intensity.
n	=	Number of pixels.

For **Line** fits there will be a separate **Deviation** result for each axis.

6.17 Correlation of Fit

The **Correlation** result gives you a relative value for how well the data matches the fitted Gaussian surface. The **Correlation** is useful in the sense that the result approaches one as the fit to the data

becomes better and vice versa. The **Correlation** gives a relative feeling for how well the data matches a Gaussian surface.

However, this result is relative, not absolute. A result of 0.8 tells us the data is a better Gaussian shape than a result of 0.7 and a worse Gaussian than 0.9, but it does not tell us how much more or less. A change from 0.85 to 0.9 tells us there was an improvement but does not tell how much.

The definition of the **Correlation** can be seen in the equation below. Dividing it by the volume of the data normalizes the relative error, |Z-S|. This allows relative comparisons of the correlation value between different samples and beams. The relative error has a potential range of zero to infinity. Therefore, the correlation has a potential range of minus infinity to one. However, we have found the practical range is between zero and one. If the correlation is less than zero, then the beam is obviously not Gaussian.

$$G_c = 1 - \frac{\sum |Z - S|}{\sum Z}$$

Where:

G_C = Gaussian correlation, $-1 < G_c \leq 1$.

Z = pixel intensity.

S = Gaussian surface intensity.

6.18 Top Hat

The **Top Hat** computations quantify laser beams that have a flat topped energy distribution with steeply sloped sides. The **Top Hat** results provide the Mean, Standard Deviation, and Minimum and Maximum energy density in a defined area on the beam's energy profile. A Top Hat Factor value is computed to indicate the overall quality of the **Top Hat** energy distribution. An Effective Area and Effective Diameter results are also computed to indicate the working area of the beam.

In general most Top Hat measurements should utilize the Percent of Peak method for determining a clip level.

The Top Hat edit control allows you to measure a **Top Hat** beam in three different ways.

1. **Data**: Only pixels with intensity levels above the **clip level** will be use to compute the Top Hat results. If an aperture is present it will further limit the analysis to the pixels inside the aperture.
2. **Area Aperture**: The Top Hat Area Aperture selection is intended to be used to analyze the data within a specific region lying on the upper surface of a Top Hat beam. Use a **Drawn Aperture** to isolate regions of the beam and compute results over the entire area enclosed by the aperture, (the clip level is ignored for all but the Effective Area and Diameter results). While this method is intended for use with a **Drawn Aperture**, it will however work with no aperture and with an Auto aperture, see the notice below.
3. **Line Aperture**: The Top Hat Line Aperture is intended to be used to analyze the data lying along the axes of a **Drawn Aperture**. As in Area Aperture above this should be limited to regions lying on the upper surface of the Top Hat beam. Except for **Top Hat Factor** a separate result will be computed for each axis of the aperture. Use a **Drawn Aperture** to isolate regions of the beam and compute results over only the orthogonal axes of the aperture, (the clip level is ignored for all but the Effective Area and Diameter results). This method is intended for use with a **Drawn Aperture**, however it will work with no aperture and with an Auto aperture, see the notice below.

*Notice: In general it is **not** advisable to use the **Auto Aperture** feature when making **Top Hat** measurements.*

6.18.1 Top Hat Mean and Standard Deviation

The computation of the **Mean** and **Standard Deviation** are described in the equations below:

for the Mean,

$$\overline{Z} = \frac{\sum Z}{n}$$

Where:

$\overline{Z}$ = Mean intensity
n = Number of summed pixels
ΣZ = Sum of the pixel intensities above the clip level, or in the area, or on the line being evaluated.

for the Deviation,

$$\sigma = \sqrt{\frac{\sum \left(Z - \overline{Z}\right)^2}{n-1}}$$

Where:

σ = std. deviation.
n = Number of pixels summed.
$\Sigma(Z - \overline{Z})^2$ = Sum of the square of the differences between the mean intensity and the pixel intensity values above the clip level, or in the area, or on the line being evaluated.

6.18.2 Top Hat Minimum and Maximum intensities

The values appearing here represent the highest and lowest energy intensities that are found within the Top Hat area, as defined by the **Data**, **Area** or **Line Aperture** selection.

Note: In **Data** *mode, the* **Minimum** *will often be the clip level value determined by the Beam Width Method.*

6.19 Top Hat Factor

The **Top Hat Factor** provides a numerical measure of quality for a Top Hat beam profile. It is a normalized value that compares your beam profile against a perfect Top Hat--a perfect Top Hat being a beam with vertical sides and an absolutely uniform intensity on the top. A Factor value of 1.0 describes a perfect Top Hat.

Examining a plot of a beam's energy fraction versus its normalized fluence derives the Top Hat Factor. The energy fraction is defined as the fraction of total energy above a particular fluence value. See figure below. If we calculate the area under the energy fraction curve, we will have a single normalized

parameter to describe quality of a Top Hat's energy distribution. A perfect Top Hat has a single fluence value that makes up 100 percent of energy and plots curve A. The area under this curve yields the Top Hat Factor value of 1.0. A Gaussian beam plots the curve labeled C. The area, and thus the Factor, for beam C is 0.5.

Real-world Top Hat beams will plot curves somewhere between A and C, such as curve B. Thus, as the area under the curve approaches unity, the quality of the Top Hat is seen to improve.

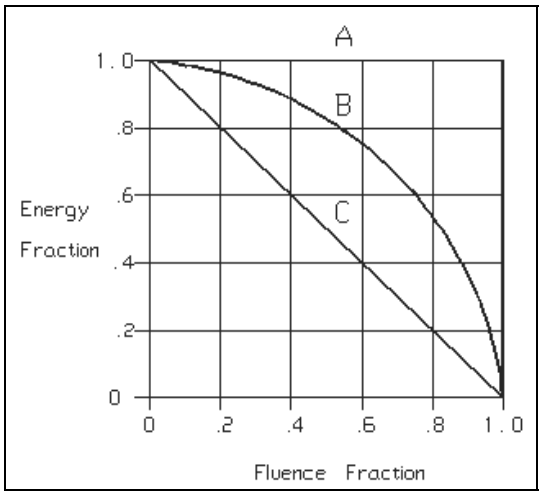


Figure 56

The equation below describes how the curve of a particular beam profile would be derived from the pixel intensity data. The plot of such a curve is formed by the sum of the product of the number of pixels and the corresponding fluence for each fluence value, in a range starting from the maximum fluence value to the current value.

$$E(f) = \sum_{i=Pk}^{f} \frac{i \times NPix}{Total}$$

Where:

E	=	The fraction of *energy* contained between the fluence value and the peak value.
f	=	The fluence value.
Pk	=	The peak fluence value.
Total	=	The total *energy* in the beam.
Npix	=	The number of pixels that have the value of I.

To find the Top Hat Factor, sum the area under the curve formed from the above equation, as shown below:

$$F = \frac{\sum_{f=1}^{Pk-1} \frac{E_f + E_{f+1}}{2}}{Pk}$$

Where:
F = The Top Hat Factor (area under the curve)

6.20 Effective Area and Effective Diameter

All of the pixels that are above the clip level are included in the **Effective Area** and **Diameter** results. If an aperture is present then the analysis is confined to just the pixels inside the aperture. The sum of the areas of all the pixels above the clip level is the **Effective Area**. The **Effective Diameter** is the diameter of a circle that will just contain the **Effective Area** as shown below:

$$ed = 2 \times \sqrt{\frac{ea}{\pi}}$$

Where:
ed = Effective diameter
ea = Effective area

6.21 Far-Field Divergence Angle computations

The LBA-PC can calculate Far Field Full-Angle beam divergence in two orthogonal axes. Two methods are provided, the **Focal Length** and the **Far-Field**. The **Focal Length** method requires the use of a focusing optic, while the **Far-Field** method requires that all measurements be performed in the far-field of your laser beam. Each method is discussed below. In each discussion you can assume results are duplicated for each axis.

6.21.1 The Focal Length Method

This method is based upon the beam width of a focused beam's spot size and the focal length of the focusing optic. **Divergence** results will be computed in the **X** and **Y** aligned axes of the beam if **Elliptical** results are disabled, or for **Major** and **Minor** axes beam orientations if **Elliptical** results are enabled.

The Focal Length divergence method provides a means for finding the far-field beam divergence at any point in the beam propagation path. As shown below, the calculation performed by the LBA is quite simple, however the optical setup must be done with great care. The user to suit his particular application must provide the optic. The focusing optic must be large enough to accommodate the input beam, without introducing diffraction effects. You can use either refracting or reflecting focusing optics, but in either case, you must place your camera's detector at the exact focal length of the optical element. The Divergence result is based upon the focused spot size as described in the equation below:

$$divergence = \tan^{-1}\left(\frac{W_f}{f}\right)$$

Where:
W_f = The width of the focused spot at distance f from the optic.

f = The focal length of the imaging optic at the wavelength of the laser.

If you are not already versed in the theory behind the Focal Length method, we recommend the following reference document:

Laser Far-Field Beam-Profile Measurements by the Focal Plane Technique, by G.W. Day and C.F. Stubenrauch, NBS Technical Note 1001, March 1978. This publication is no longer in print. A copy can be obtained from the Spiricon Sales or Service department.

6.21.2 The Far-Field Method

This method is based upon the actual measured increase in laser beam width as it expands in the far-field region. Before using this method, be sure that your measurements will be made in the beam's far-field region, and the size of the beam does not grow larger than your camera's ability to contain it. **Divergence** results will be computed in the X and Y aligned axes of the beam if **Elliptical** results are disabled, or for Major and Minor axes beam orientations if **Elliptical** results are enabled.

*Notice: We strongly recommend that you **do not** use the* **Elliptical** *mode when using the* Far-Field *method, but rather rotate your camera to bring the axes of the laser into X and Y alignment.*

Position the camera in the beam path to acquire a first, or **Reference**, beam width. It is assumed that this first sample will be the one nearest the beam waist, and thus the smaller sample width. Next, move the camera a distance further from the beam waist. Note the distance the camera has traveled as the **Separation** distance. The Divergence result is computed as follows:

$$divergence = 2 \cdot \tan^{-1}\left(\frac{W_C - W_R}{2 \cdot S}\right)$$

Where:

W_R = The width of the beam at the Reference (nearer to the waist) location.
W_C = The width of the beam at the Current (further from the waist) location.
S = The separation distance between the two beam width sample locations.

6.22 Histogram

The LBA-PC can produce a fluence **Histogram** of the currently displayed frame of data. Each bar in the display represents a fluence **Bucket**. Each **Bucket** describes a range of quantized fluence values. The minimum **Bucket Size** is based upon a single count of the digitized output of the A to D converter. The Bucket will be scaled if energy calibration is in use. With energy calibration in effect, the raw values are simply multiplied by a scaling factor that converts them to energy densities. For simplicity, all of the following discussions will assume no *energy* calibration. Thus, a raw A to D pixel intensity range of from 0 to 255/1023/4095/16383/32767 will be assumed.

Image processing can alter the numerical value of a pixel's intensity. Ultracal, Reference Subtraction, Frame Averaging and Frame Summing are all processes that transform the simple 8/10/12/14/15 bit integer input from the A/D conversion, into a signed 16 bit fixed point value. For ease of use, we have forced all buckets to be defined in raw pixel integers. Thus a Bucket size of 4, starting at zero, will contain the intensity values from 0 to 3.992, the next bucket goes from 4 to 7.992, and so on.

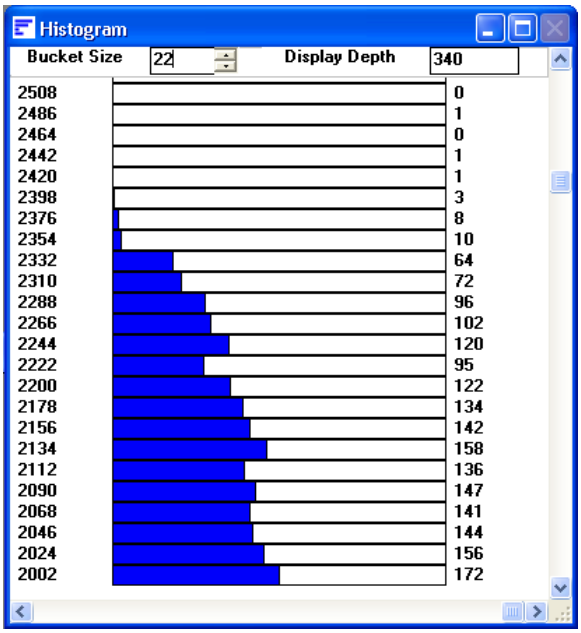


Figure 57

The numbers displayed along the left edge of the **Histogram**, indicate the lower value of each **Bucket**. The numbers along the right edge of the display is the total count of the number of pixels that have been placed into each of the Buckets. The length of the drawn bar represents the depth to which the Bucket is filled. Zero count is on the left.

The horizontal scale can be magnified with the **Horizontal Scroll Bar**, the **Vertical Scroll Bar** allows you to bring into view Buckets that may extend higher than your display resolution will accommodate.

6.23 Statistics

Statistical results can be obtained for any enabled computational item. The Statistical results are **Mean**, **Standard Deviation**, **Maximum**, and **Minimum**. The number of samples used in computing each result is indicated on the top line of the results.

The computation of the **Mean** and **Standard Deviation** are described in the equations below:

for the Mean,

$$\bar{s} = \frac{\sum_{n=1}^{n} S}{n}$$

Where:

$\bar{s}$ = Mean.

ΣS = Sum of the samples.

n = Number of samples.

for the Standard Deviation,

$$\sigma = \sqrt{\frac{\sum_{n=1}^{n}\left(S - \bar{s}\right)^2}{n-1}}$$

Where:

σ	=	std. deviation.
n	=	number of samples.
$\Sigma(S - \bar{s})^2$	=	sum of the square of the differences between the mean and each sample.

The **Maximum** and **Minimum** are just the largest and smallest values encountered in the samples.

6.24 Frame Averaging

The signal to noise ratio of the digitized data can be improved by using **Frame Averaging**. The amount of the improvement is roughly the square root of the number of frames being averaged. The LBA-PC can average a maximum of 256 frames for at best a 16 times improvement of the signal to noise ratio. The amount of improvement is also limited by the noise content of your camera and our digitizer system. In general you will begin to receive diminishing returns when you average more frames than the square of the number of noise counts. For CCD cameras the noise is about 4-5 counts, so averaging more than 16 to 25 frames will be of little benefit.

Pulse to pulse variations for a pulsed laser will be reduced by a like amount.

When **Frame Averaging** is enabled, the display will update with the averaged results only after all frames have been received. Any calculations will similarly be performed only after all frames have been received.

***Notice**: When Frame Averaging is enabled and you click on* **Stop**!*, the LBA will immediately abort the collection of frames for averaging and will display the last completed set of averaged data. Any frames that were in the process of being averaged are discarded, thus when you again click* **Start**! *a totally new averaging process is begun.*

***Notice**: **Do Not** use Frame Averaging if your beam suffers from poor pointing stability, and you want to make accurate beam width measurements. Instead, enable statistics and find the mean beam width by using results averaging. This is independent of centroid position.*

6.25 Frame Summing

You can use **Frame Summing** to observe the cumulative effect of a pulsed laser. The LBA-PC can sum a maximum of 256 frames. Be careful that your pulse rate is not greater than the LBA and Camera system can keep up with, and that the total energy doesn't exceed the available dynamic range. Note: You may want to use block mode to insure that you do not miss any pulses.

Frame summing will cause fixed pattern noise to increase in proportion to the number of frames summed, while temporal noise will increase only as the square root of the number of frames being summed. Thus some improvement in the signal to noise ratio will be realized. To further improve the signal to noise ratio, try using **Frame Summing** together with **Frame Averaging**.

When **Frame Summing** is enabled, the display will update with the summed results only after all frames have been received. Any calculations will similarly be performed only after all frames have been received.

***Notice**: When Frame Summing is enabled and you click on **Stop**!, the LBA will immediately abort the collection of frames for summing and will display the last completed set of summed data. Any frames that were in the process of being summed are discarded, thus when you again click **Start**! a totally new summing process begins.*

6.26 Gamma Correction

If your camera has a gamma value less than or greater than 1, the LBA can be set to correct for your cameras non-linear response. Enter the gamma of the camera in the **Gamma** edit control in the **Camera..** dialog box. Each pixel of each new frame of data will be automatically corrected as defined in the equation shown below. If you enter a value of 1, gamma correction is disabled.

$$z = \left(\frac{Z}{P}\right)^{1/g} \times P$$

Where:

z	=	Gamma corrected pixel intensity
Z	=	Uncorrected pixel intensity value
g	=	Gamma
P	=	255/1023/4095/16383/32767

***Notice:** Be sure of your Gamma correction value. If necessary, run a response curve on your camera. Standard published gamma values are usually averages for particular tube types and may not always be adequate for obtaining the desired accuracy. Also, be wary of gamma values less than 1 published for CCD cameras. These values are usually approximations obtained by using two-piece linear fits to an exponential gamma curve. Whenever possible use CCD cameras which are settable to a gamma of 1.*

6.27 Convolution

Convolution algorithms in the LBA-PC may take on a number of forms, some of which might not fit the exact description that is to follow. In the broadest sense, convolution refers to a general-purpose algorithm that can be used in performing a variety of area process transformations. One such general-purpose algorithm will be described here.

For the purpose of this description, the best way to understand a convolution is to think of it is a weighted summation process. Each pixel in an image becomes the center element in a neighborhood of pixels. A similarly dimensioned **convolution kernel** multiplies each pixel in the neighborhood. The sum of these products is then used to replace the center pixel.

Each element of the **convolution kernel** is a weighting factor called a convolution coefficient. The size and arrangement of the convolution coefficients in a convolution kernel determine the type of area transform that will be applied to the image data.

The figure below shows a 3x3 neighborhood and convolution kernel.

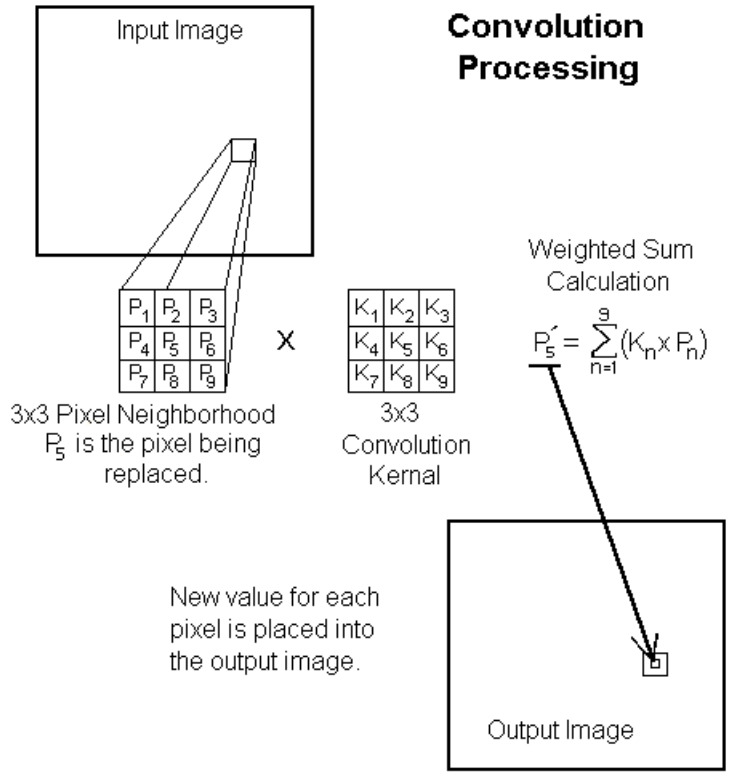


Figure 58

The tables below give the convolution coefficients (K values) for some of the included low-pass spatial filters.

1/9	1/9	1/9
1/9	1/9	1/9
1/9	1/9	1/9

LPF 1-3X3

1/10	1/10	1/10
1/10	1/5	1/10
1/10	1/10	1/10

LPF 2-3X3

1/16	1/8	1/16
1/8	1/4	1/8
1/16	1/8	1/16

LPF 3-3X3

1/25	1/25	1/25	1/25	1/25
1/25	1/25	1/25	1/25	1/25
1/25	1/25	1/25	1/25	1/25
1/25	1/25	1/25	1/25	1/25
1/25	1/25	1/25	1/25	1/25

LPF 1-5X5

1/49	1/49	1/49	1/49	1/49	1/49	1/49
1/49	1/49	1/49	1/49	1/49	1/49	1/49
1/49	1/49	1/49	1/49	1/49	1/49	1/49
1/49	1/49	1/49	1/49	1/49	1/49	1/49
1/49	1/49	1/49	1/49	1/49	1/49	1/49
1/49	1/49	1/49	1/49	1/49	1/49	1/49
1/49	1/49	1/49	1/49	1/49	1/49	1/49

LPF 1-7X7

Low-Pass Spatial Filter Convolution Coefficients

Figure 59

Chapter 7 DIGITAL CAMERA OPTION

7.1 Digital Camera Option

This section will discuss how to interface a Digital Camera with an **LBA-400/500/700/708/710/712/714PC-D** equipped with the Digital Camera Option. This option is identified by the presence of a **–D** in the title bar model designation. The frame grabber will also be provided with a short ribbon cable adapter that plugs into the frame grabber and has a 50 pin connector attached to a PC mounting bracket.

7.2 I/O Connections

The digital camera connector is a 50 pin standard SCSI-2 style, however the circuit connections are NOT SCSI compatible. A typical compatible cable assembly is AMP 750254-2. Sample compatible connector / cable components are:

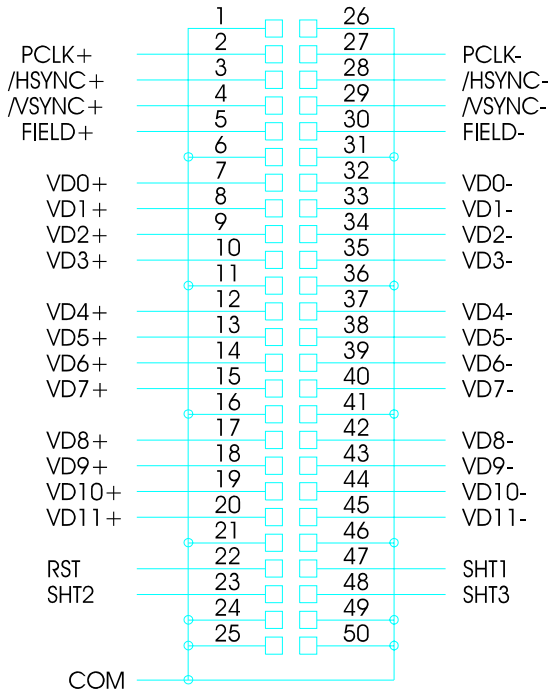
- Plug AMP 750913-5 for .032”-.036” OD, 28 awg wire
- Plug AMP 1-750913-5 for .029”-.031” OD, 28 awg wire
- HousingAMP 749193-2 for .400” max. cable OD
- Cable Madison SPEC4084-5A, or 50SD08TIA

The signal inputs to the LBA must be differential **RS-422 or RS-644 (LVDS)** compatible. Each input pair is terminated into 110 ohms at the LBA-PC. For good noise immunity and signal integrity, we recommend a twisted pair cable with a characteristic impedance of about 100-120 ohms per pair with an overall shield.

There is not an industry standard for digital camera connectors, so each camera type will require a custom interface cable assembly. Consult your camera operator’s manual for particular connector requirements. Most cameras will have similar output signal functionality, while each will have slightly different signal timing properties.

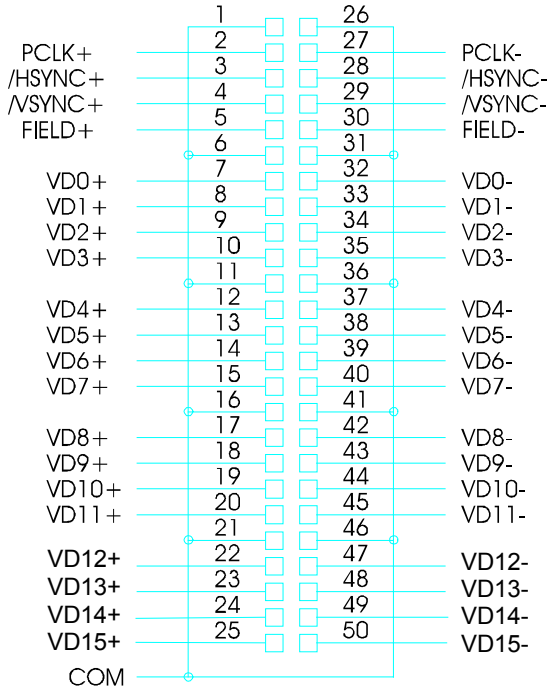
The Figures below describes the signal pin outs for the 50-pin digital camera connector based on the model frame grabber in use. The first figure is for the older LBA-400/500 models while the second figure is for the newer LBA-7XX models.

Note: Cables for LBA-400/500 models that support 12 bit cameras will work as is with the LBA-7XX models. Cables for 8 or 10 bit cameras are not compatible with the LBA-7XX models and must either be rewired or replaced with newer designs. Contact the Spiricon Service or Sales department to resolve any camera cable compatibility issues.



Digital Camera Connections for LBA-400/500 Model Frame Grabbers

Figure 60



Digital Camera Connections for LBA-7XX Model Frame Grabbers

Figure 61

Signal definitions are as follows: References to LBA settings are found in either the **Camera** or **Camera Advanced** dialog boxes. For digital cameras, set the **Sync Source** to **Digital**.

PCLK+/-

Connect your camera's pixel clock to this input. Either the rising or falling edge of this signal will denote the time when your camera's pixel data should be sampled. If your camera data is to be sampled by the falling edge of PCLK+, set the ERC Polarity to Positive. If your camera data is to be sampled by the rising edge of PCLK+, set the ERC Polarity to Negative. Pixel clock frequencies below 15MHz will allow large mega-pixel cameras to interface with the largest image sizes. Cameras with high clock frequencies will require a reduction of the image size that can be acquired. We have successfully interfaced cameras with clock rates at 25MHz, but with a loss in image width. This will vary from camera to camera depending upon how the image is formatted.

/HSYNC+/-

Connect your camera's horizontal sync (or start of line/row) to this input. If /HSYNC+ is a negative going pulse set the Sync Polarity to Negative. If /HSYNC+ is a positive going pulse set the Sync Polarity to Positive. Note the polarity of the HSYNC and VSYNC signals must be the same.

/VSYNC+/-

Connect your camera's vertical sync (or start of frame/field) to this input. If /VSYNC+ is a negative going pulse set the Sync Polarity to Negative. If /VSYNC+ is a positive going pulse set the Sync Polarity to Positive. Note the polarity of the /HSYNC+ and /VSYNC+ signals must be the same.

FIELD+/-

This signal is only used when the camera Scan Mode is Interlaced. Most digital cameras are sequentially scanned, i.e. Non-interlaced. If your camera is interlaced, this signal will indicate to the LBA which field is being input. FIELD+ must go high during the Odd or 1st field time, and must go low during the Even or 2nd field time. It should change state at the beginning of VSYNC.

VD11-0+/-... LBA-400/500

Connect the digital data signals to these inputs. VD11 is the MSB and VD0 is the LSB. Connect the MSB from your camera to VD11. Unused connections must always involve the LSB's. VD+ must be a logic high to denote a true condition of a data bit. Set the Pixel Bits value to the number of data connections supported. Note: If the output from your digital camera is in a signed two's compliment data format, connect the sign bit to VD11, and the MSB data to VD10. The Pixel Bits entry should be a negative value for signed data. For example: If your data is a 12 bit signed two's compliment format, enter a -12 for the Pixel Bits.

VD15-0+/-… LBA-7XX

Connect the digital data signals to these inputs. VD11 is the MSB and VD0 is the LSB. Connect the LSB from your camera to VD0. Unused connections must always involve the MSB's. VD+ must be a logic high to denote a true condition of a data bit. Set the Pixel Bits value to the number of data connections supported. Note: If the output from your digital camera is in a signed two's compliment data format, connect the sign bit to the bit just above the cameras MSB data bit. The Pixel Bits entry should be a negative value for signed data. For example: If your data is a 12 bit signed two's compliment format, enter a -12 for the Pixel Bits.

At the present time 16 bit cameras are supported as 15 bit devices, VD15 is not usable. If you are connecting a 16 bit camera connect the 15 MSB's to VD0 through VD14

COM

A number of signal common, or ground, connections should be made between your camera and the LBA. Although not required for operation, an outer case-to-case shield connection is also recommended.

The above connections are the minimum requirements for successful interfacing of a digital camera to the LBA-PC.

The following additional signals are outputs from the LBA-400/500PC models that provide control for an electronic shutter, if your camera is so equipped.

SHT#… LBA-400/500 ONLY

These three signal outputs are available to control an electronic shutter. For these signals to become operational, the **Shutter** check box must be checked. You can enter the Shutter speeds in the supplied dialog box. Be sure to save the camera configuration into a .cam file once you've completed these entries.

RST… LBA-400/500 ONLY

This signal output is reserved and has no function at this time.

Special Jumper Cutting Requirements: LBA-400/500 ONLY

Special circumstances can arise if your digital camera has a contrary number of digital outputs than the LBA-400/500PC can support.

- The LBA-400PC can support a maximum of 10 data bits.
- The LBA-500PC can support a maximum of 12 data bits.

If your camera has more digital outputs than the LBA has inputs, use the upper MSB's from your camera, starting with VD11 on the LBA.

If your camera has fewer data output signals than the LBA has inputs, then use the upper most data inputs, starting at VD11, and cut open the following jumper traces:

- For an LBA-500PC with a 10 bit digital camera, cut open E7 and E8.
- For an LBA-500PC with an 8 bit digital camera, cut open E7, E8, E9 and E10
- For an LBA-400PC with an 8 bit digital camera, cut open E9 and E10.

Note: Jumper cuts are made between square shaped circuit pads labeled with "E#" designators. An Exacto knife with a sharp blade is recommended for making these cuts. If you are unsure how to go about performing these small surgical like operations then please call Spiricon's service department and we can walk you through it.

7.3 Digital Camera Advanced Timing Setup

The following **Camera**, **Advanced** settings; **Transfer Mode**, **Scan Mode**, **Horizontal Start**, **Horizontal Size**, **Vertical Start** and **Vertical Size**, must be correctly set in order to capture and display the data transmitted from your digital camera. These settings are best accomplished by making a few good guesses and then modifying your results by trial and error. You will need to know:

- Is your camera operating in an Interlaced or Non-Interlaced (Progrssive scan) mode?
- If your camera is interlaced, does it use a **Frame** transfer style detector?
- What are the total number of HSYNC's (lines or rows) that your camera outputs per VSYNC (or frame, if interlaced) of video?
- How many of those rows are black, and how many contain real data, and where are they?
- How many total pixel clocks are output per HSYNC (line or row) of data?
- How many of those clocks have black data, and how many contain real data, and where are they?

7.3.1 Transfer Mode

If your camera is an interlaced or pseudo interlaced frame transfer style set the mode to **Frame**. If your camera is a non-interlaced (progressive) scan style that uses either Interline or Full-frame transfer style imagers set the mode to **Interline**. For most CMOS, X/Y and line scanning camera set the mode to **Line**.

7.3.2 Scan Mode

If your camera is interlaced select **Interlaced**. If non-interlaced, or progressive scanned, choose **Non-interlaced**.

7.3.3 Vertical Start

This value must be an even number. Enter the row where video data begins. If your camera is non-interlaced, and outputs a total of 300 rows, where the first 24 rows are black followed

by 256 rows of video and then 20 rows of black, try a first value of 18 (24-6) for **Vertical Start**. If your camera is interlaced, and each frame outputs a total of 525 rows (i.e. 262.5 rows per field), and the first 32 rows of each frame are black, followed by 490 rows of video per frame, try a first value of 20 (32-12) for **Vertical Start**.

7.3.4 Vertical Size

This value must always be an even number: Enter the number of rows that contain video data. In the above Vertical Start examples set this value to 256 in the first example, and 490 for the second example. Before the release of software version 4.xx, this value was limited to a maximum of 1000 rows. After version 4.xx this value maximum is 2000 rows. It is a good idea to start with a value 50 to 80% less than the maximum for your camera and then work up to a number that the frame grabber can actually support. This is particularly important for mega-pixel style cameras.

7.3.5 Horizontal Start

This value must be an even number. Enter the pixel clock where the video data begins. A good starting value is approximately half the number of clocks from the end of HSYNC. For example: Suppose the first active pixel is 25 PCLK's after the end of HSYNC. Enter a first value of 12 for **Horizontal Start**.

7.3.6 Horizontal Size

This value must be an even number. Enter the number of active pixels in each horizontal row. Before the release of LBA software version 4.xx, this value was limited to a maximum of 1000 pixels. After version 4.xx this value maximum is 2000 pixels. It is a good idea to start with a value 50 to 80% less than the maximum for your camera and then work up to a number that the frame grabber can actually support. This is particularly important for mega-pixel style cameras with high-speed pixel clocks. Pixel clock frequencies below 15MHz will allow large mega-pixel cameras to interface with the largest image sizes. Cameras with high clock frequencies will require a reduction of the image size that can be acquired. We have successfully interfaced cameras with clock rates at 25MHz, but with a loss in image width. This will vary from camera to camera depending upon how the image is formatted.

After making the above settings click **Start**! and see if you are able to acquire some data frames. At this point, it is best to operate in Continuous capture and CW trigger mode. Also make sure that your Zoom setting is indicating X1 resolution and the Lens check box is not checked. If the above guesses were close, you should be acquiring data frames. If not, then further reduce the **Vertical Start** and **Horizontal Start** values until data frames are collected.

With your camera detector illuminated you should see the boundary of two sides of your camera's detector, that is unless one or both of the above guesses turn out to be exactly correct. The next step is to adjust the **Vertical Start** and **Horizontal Start** values such that the camera image is set to just fill the acquired data window. Note: It is not a necessity that you configure the capture width and height to acquire all the data output by your camera. If you only want to input a portion of the detector you can reduce the **Vertical Size** and **Horizontal Size** to smaller values.

Adjust the **Vertical Start** value according to the following rules. (Remember you must input even values.) To move the image **DOWN**, decrease the Vertical Start value. To move the image **UP**, increase the **Vertical Start** value.

Adjust the **Horizontal Start** value according to the following rules. (Remember you must input even values.) To move the image **LEFT**, decrease the **Horizontal Start** value. To move the image **RIGHT**, increase the **Horizontal Start** value.

When the image is centered be sure to save a <camera>.cam and a <config>.cfg configuration so that you can restore these setup conditions.

7.4 Digital Camera and Ultracal Operation

The Ultracal! operation can be adversely affected by how your digital camera is adjusted. Some digital cameras will have their A to D converter black levels set such that some or all of the negative pixel energy is clipped at Zero. Some may even clip a portion of the positive signal region. From the LBA-PC's point of view, a properly adjusted camera will never generate a Zero pixel value, thus preserving all of the black baseline negative temporal noise. If your camera has a straight binary output then the Ultracal! operation will yield one of the following three results:

1. If your output image data contains zero pixel values, you will get a warning message that the calibration will not be as accurate as normal. The Ultracal enunciator will turn GREEN to indicate that the obtained calibration results are being used as best as possible
2. If your output image does not contain zero pixel values and the signal is fairly low in magnitude, then the calibration will proceed normally and the results will be good. The Ultracal enunciator will turn GREEN.
3. If your output image does not contain zero pixels, but the image is bright due to a high offset, then a warning message will appear that will ask you to block your beam from the camera. Click OK to accept these conditions. The Ultracal enunciator will turn GREEN.

If the first or third result occurs you may be able to correct this condition by adjusting the black threshold of your camera's A to D converter. Here is how to proceed. With the LBA uncalibrated and your laser energy blocked from reaching the camera detector, observe the "Min" and "Max" energy values. If Zero's appear, your camera is set to clip some or all of the negative baseline noise. If these values are running too high the LBA will think you have laser *energy* hitting the imager. Check your camera operator's manual to see if a black level adjustment is provided. If you can adjust the black level, do so until the Min. *energy* value never indicates Zero and the Max. *energy* value is as low as possible. Now try to run an Ultracal! and see if the results are as in 2 above.

Note: Almost all cameras will exhibit baseline drift. When making adjustments to your camera always allow the camera to come to thermal equilibrium and allow a little headroom on the adjustments to accommodate additional drift over time and temperature variations

.

If your camera does not have a black level adjustment, and gives on of the above warnings then you must either accept the reduced accuracy or have your camera manufacturer modify the camera for you.

If your camera has a signed two's compliment data format, the Ultracal! function will be disabled. Under this condition it is assumed that the camera is self-calibrating, or provides a calibration capability to the operator.

Chapter 8 REMOTE OPERATION

8.1 Remote Operation

The LBA-PC has nearly full GPIB remote control capabilities and partial ActiveX remote control capabilities. During the installation phase you were asked if remote operation was required. If you answered yes to the query, the installation process will have loaded the appropriate device drivers that allow the LBA-PC to communicate with a National Instruments GPIB interface card. The ActiveX servers are always available.

If you installed the remote operation by mistake, see How to Disable Remote Operation in section 8.2.

Note: The LBA-PC application will only support National Instrument GPIB device drivers. For a list of the supported NI GPIB cards see Chapter 10.

Remote operation of the LBA-PC can be a simple operation or very complex, depending upon the magnitude of the remote control task. Spiricon's Service Department will supply some limited free technical support, but must charge for support that becomes more than basic question and answer queries. Spiricon's engineering department can provide full Remote Control applications developed in National Instruments LabVIEW graphical programming language. Contact Spiricon's service or sales department for information regarding custom LabVIEW virtual instrument development support.

All information regarding LBA-PC remote control is provided in Chapters 9 & 10.

8.2 How to Disable Remote Operation

The LBA-PC remote control capability is contained in the file **REMOTE.DLL** that is copied to the directory you specified during the LBA-PC installation. The default installation directory is \SPIRICON\LBAPC\. If you do not have a National Instruments GPIB card, or the GPIB device drivers are not loaded, then you will see an error message every time the LBA-PC application is started. To avoid this error message, and disable the LBA-PC remote capability, you must go to the main installation directory and delete the **REMOTE.DLL** file.

If you later wish to restore remote capability, copy the file **REMOTE.DLL** from the \SPIRICON\LBAPC\Remote directory on the Spiricon CD to the main installation directory or reinstall the LBA-PC software.

Chapter 9 ACTIVE X

9.1 Introduction

The LBA-PC ActiveX server provides simple control of LBA-PC along with access to frame data, beam display image, results, statistics, and pass/fail indicators. The LBA-PC ActiveX server runs under Windows 2000 and Windows XP Professional.

Using the LBA-PC ActiveX server, you can:

- Start and Stop collecting and processing new data frames
- Initiate an Ultracal cycle
- Restore a LBA-PC configuration from file
- Read new data frames and limited frame information
- Read a bitmap image of the beam display image
- Read computed results
- Read statistical results
- Reset statistical results
- Read pass/fail indicators

Using the LBA-PC ActiveX server, you cannot:

- Detect or handle LBA-PC errors or error messages
- Get or set the LBA-PC configuration
- Read random data frames

9.2 Using ActiveX

Many modern development languages such as Visual Basic, Visual C++, and Borland C++ Builder support ActiveX. Many applications such as Microsoft Word, Microsoft Excel, and National Instruments LabVIEW also support ActiveX. Development languages and applications all use different methods for accessing ActiveX controls.

Below we will briefly describe how to use the LBA-PC ActiveX server in Microsoft Excel, Visual Basic, and LabVIEW.

9.2.1 Microsoft Excel

Visual Basic for Applications (VBA) is integrated into Microsoft Excel. Follow these steps to use the LBA-PC ActiveX server in Microsoft Excel:

1. Create a new Workbook in Excel

2. Go to the Visual Basic Editor. On the **Tools** menu, select **Macro**, and then select **Visual Basic Editor**. A new VBA window will open.
3. Reference the LBA-PC ActiveX server. On the **Tools** menu, select **References...** Scroll down until you see **LbapcActiveX EXE**. Select the checkbox to the left of **LbapcActiveX EXE**.
4. For this example, we will use the LBA-PC ActiveX server in a form. Create a new form. On the **Insert** menu, select **UserForm**. A form is displayed in a new window.
5. Add controls to the form such as Start/Stop/Ultracal buttons, etc.
6. Declare a variable to hold a LBA-PC ActiveX server object. On the **View** menu, select **Code**. A new window appears with an outline of the UserForm_Click() subroutine. At the top of the code window, above the UserForm_Click() Function, type "Dim WithEvents LbapcActiveX As LbapcX.LbapcActiveX" without the quotation marks.
7. Initialize the LbapcActiveX object and initialize communication with LBA-PC. There are two list boxes at the top of the code window. In the left list box, select **UserForm**. In the right list box, select **Initialize**. A new subroutine called UserForm_Initialize() is created. In this subroubtine type "Set LbapcActiveX=New LbapcX.LbapcActiveX" without the quotation marks. This statement creates a new LBA-PC ActiveX server object and assigns it to the LbapcActiveX variable. On the next line, type "LbapcActiveX1.Open" without the quotation marks. This statement initiates communication between the LBA-PC ActiveX server and LBA-PC.
8. Respond to LBA-PC ActiveX events. In the left list box, select **LbapcActiveX**. A new subroutine called LbapcActiveX_OnNewFrame() is created. This subroutine is called every time the LBA-PC collects a new frame of data.
9. Do something during the event. In LbapcActiveX_OnNewFrame() subroutine type "Range("B2").Value = LbapcActiveX.Results(0)" without the outer quotation marks. This statement puts the frame Total result in cell B2.

An example Workbook, LbapcActiveXExample.xls, can be found in "ActiveX\Examples\Excel" directory under the LBA-PC installation directory.

9.2.2 Visual Basic (Visual Studio)

In this section, Visual Basic refers to the Visual Basic part of the Microsoft Visual Studio family of development products. Follow these steps to use the LBA-PC ActiveX server in Microsoft Visual Basic:

1. Start a new Visual Basic project.
2. Reference the LBA-PC ActiveX server. On the **Project** menu select **References...** Scroll down until you see **LbapcActiveX EXE**. Select the checkbox to the left of **LbapcActiveX EXE**.
3. Declare a variable to hold a LBA-PC ActiveX server object. On the **View** menu select **Code**. A new code window appears. At the top, type "Dim WithEvents LbapcActiveX As LbapcX.LbapcActiveX" without the qutotation marks.
4. Initialize the LbapcActiveX object and initialize communication with LBA-PC. There are two list boxes at the top of the code window. In the left list box select **Form**. An outline of the Form_Load() subroutine is placed in the code window. . In this subroutine type "Set LbapcActiveX=New LbapcX.LbapcActiveX" without the quotation marks. This statement creates a new LBA-PC ActiveX server object and assigns it to the LbapcActiveX variable. On

the next line, type "LbapcActiveX.Open" without the quotation marks. This statement initiates communication between the LBA-PC ActiveX control and LBA-PC.

5. Respond to LBA-PC ActiveX events. . In the left list box, select **LbapcActiveX**. A new subroutine called LbapcActiveX_OnNewFrame() is created. This subroutine is called every time the LBA-PC collects a new frame of data.

An example Visual Basic project, LbapcActiveXExample.vbp, can be found in "ActiveX\Examples\Visual Basic" directory under the LBA-PC installation directory.

9.2.3 LabVIEW

Follow these steps to use the LBA-PC ActiveX control in National Instruments LabVIEW:

1. Place an ActiveX reference on the Front Panel. On the Controls palette, select **ActiveX**, and then select **Automation Refnum** (you cannot use ActiveX Object). Place the control on the Front Panel.
2. Reference the LBA-PC ActiveX server. Right click on the Automation Refnum and select **Select ActiveX Class**, then select **Browse...** Expand the list box at the top then scroll down and select **LbapcActiveX EXE**. Click OK.
3. Display the Diagram window. On the **Window** menu, select **Show Diagram**.
4. Open a connect to the LBA-PC ActiveX server. On the **Functions** palette select **Communications** then select **ActiveX** then select **Automation Open**. Place this VI on the diagram. Connect a wire from LbapcX.ILbapcActiveX node to the input **Automation Refnum** terminal of the Automation Open VI. The output Automation Refnum terminal is the reference for all LBA-PC ActiveX server properties, methods, and events.
5. To access a LBA-PC ActiveX property, right click on the LbapcX.ILbapcActiveX node, select **Create**, select **Property**, and then select the desired property from the list. Connect a wire from the output Automation Refnum terminal to the **reference** terminal of the property node.
6. To call a LBA-PC ActiveX method, right click on the LbapcX.ILbapcActiveX node, select **Create**, select **Method**, and then select the desired property from the list. Connect a wire from the output Automation Refnum terminal to **reference** terminal of the method node.
7. See the Events section of this document, and the OnNew examples for information on how to use LBA-PC ActiveX events in LabVIEW.

Example VI's are packaged in LbapcActiveX.llb, which can be found in the "ActiveX\Examples\LabVIEW" directory under the LBA-PC installation directory. The LabView examples were developed and tested using LabVIEW Professional 6i. Please note, some of the example VI's use advanced National Instruments VI's that are not part of the base package. In order to use all of the example VI's you must have the LabVIEW Full, Professional, or Developer Development System.

9.3 Properties, Methods, and Events

ActiveX components operate on the PME system, where PME is:

Properties - Think of these as data items

Methods	- Functions you can call to perform some operation
Events	- Notification when things happen

9.3.1 Properties

9.3.1.1 AppInfo

AppInfo is a two-dimensional array of integer packaged as a Variant. The leftmost dimension is 0 to 31 and the rightmost is 0 to 2. This array contains information about LBA-PC applications that are running and available for ActiveX connection. AppInfo is used to decide which application to connect to and which index to send to the OpenIndex method.

The array is formatted as follows:

[][0] = Application type
[][1] = Model Number
[][2] = Serial Number

Application type will always contain a value of 11 to indicate LBA-PC. Other Spiricon software products have other numbers, but the LBA-PC ActiveX server will only find LBA-PC applications.

Model Number will contain 1 for LBA-PC with a framegrabber or 2 for LBA-PC connected to a Pyrocam III.

Serial Number will contain the serial number of the framegrabber or Pyrocam III respectively.

Not all array rows will contain application information. If the Application type is 0 then that row does not contain application information. Row 0 will never contain application information. Application indices are fixed at launch and remain until the application is closed. The first LBA-PC gets index 1, the second gets index 2, etc. When an application is closed the index is released. If you close application 1, then row 1 Application type will be set to 0, but row 2 through 31 will still contain any previous application information.

9.3.1.2 Running

This property indicates the status of the LBA-PC data collection. This property returns TRUE if the LBA-PC is collecting data frames. Otherwise, this property returns FALSE.

9.3.1.3 OperationComplete

This property indicates the status of the Ultracal operation.

This bit flag is defined as follows.

Ultracal complete	0x0001
Auto Exposure complete	0x0002

Values are added to this property but never removed. Write a 0 to reset this property.

9.3.1.4 OperationError

This property indicates any previous operation errors.

This bit flag is defined as follows:

0x0001	Attempt to Start running while Ultracal or Auto Exposure
0x0002	Attempt to Ultracal or Auto Exposure while running
0x0004	LoadConfig method failed

Values are added to this property but never removed. Write a 0 to reset this property.

9.3.1.5 NewFrame, HoldNewFrame

These properties can be used for polling when a new frame is collected by LBA-PC and to hold the data, bitmap, picture, results, statistics, and pass/fail flags.

The NewFrame property is set TRUE each time the LBA-PC collects a new frame of data. You must reset NewFrame to FALSE to detect when the next new frame of data is collected.

If HoldNewFrame is TRUE, then the data, bitmap, results, statistics, and pass/fail flags will not change until you reset NewFrame to FALSE. (The LBA-PC will continue collecting and processing frames of data)

9.3.1.6 FrameData, FrameWidth, FrameHeight

These properties provide LBA-PC data frames and information about the data.

FrameData is a two dimensional array of double packaged as a Variant. The leftmost dimension is the number of rows and has the range 0 to FrameHeight -1. The rightmost dimension is the number of columns and has the range 0 to FrameWidth -1. The FrameData is in the same order as displayed in the LBA-PC Beam Display Window, top to bottom, left to right.

9.3.1.7 PixelHScale, PixelVScale

These properties are the horizontal and vertical pixel scales. The scale units are specified in the LBA-PC Options | Camera dialog.

9.3.1.8 FrameMonth, FrameDay, FrameYear

These properties provide the date when the frame was collected.

9.3.1.9 FrameHour, FrameMinute, FrameSecond, FrameMilliseconds

These properties provide the time when the frame was collected.

9.3.1.10 CursorX, CursorY, CursorZ

These properties provide the cursor x and y location, and the value of the pixel at the cursor.

9.3.1.11 CrosshairX, CrosshairY, CrosshairZ

These properties provide the crosshair x and y location, and the value of the pixel at the crosshair.

9.3.1.12 CursorDelta

This property provides the straight-line distance from the cursor to the crosshair.

9.3.1.13 EnergyOfBeam

This property lets you calibrate the LBA to the *energy* of your laser. Setting this property is identical to setting Energy of Beam in the LBA-PC Computations dialog. See sections 3.2.6.1 and 3.2.6.2 in the LBA-PC Operator's Manual for a detailed description of Energy of Beam and the Energy of Beam calibration procedure.

9.3.1.14 Bitmap

This property is a one-dimensional array of integer packaged as a Variant. This information can be used to create a Windows bitmap or a LabVIEW picture.

Bitmap is an exact copy of the LBA-PC Beam Display Window. If the cursor is on then the cursor will appear in the bitmap, if the color bar is on then the color bar will appear in the bitmap, etc.

The data in the array is packed as follows:

BitmapInfoHeader	Windows BITMAPINFOHEADER structure
Palette	256 element array of Windows PALETTEENTRY
Bits	Two-dimensional array of byte. The size of this array is specified in BitmapInfoHeader.biSizeImage

In LabVIEW, convert this property using the 'Variant To Data' VI, and then pass the resulting array to the LbapcBitmap.vi. The output from this VI is a LabVIEW picture. OnNewBitmap.vi contains an example of receiving and displaying a picture using the OnNewFrame event. Utility and example VI's are packaged in LbapcActiveX.llb, which can be found in the "ActiveX\Examples\LabVIEW" directory under the LBA-PC installation directory. Please note, you must have the LabVIEW Full, Professional, or Developer Development System in order to use OnNewBitmap.vi

In Visual Basic, pass this property to the BitmapPicture function in BitmapPicture.DLL. The output from this function is a StdPicture which can be used anywhere a picture is allowed. BitmapPicture.DLL can be found in the "ActiveX\Examples\Visual Basic" directory under the LBA-PC installation directory. An example Visual Basic project, LbapcActiveXExample.vbp, shows you how to declare and call the BitmapPicture function. This project can be found in "ActiveX\Examples\Visual Basic" directory under the LBA-PC installation directory.

9.3.1.15 FrameNumber

This property is the frame number as displayed in the lower right corner of LBA-PC.

9.3.1.16 Results

This property provides all of the LBA-PC results, except statistics, in a one-dimensional array of doubles packaged as a Variant.

The results are loaded into the array in the following order:

1. Quantitative
2. Elliptical
3. Gauss Fit – whole beam
4. Gauss Fit – major axis
5. Gauss Fit – minor axis
6. Top Hat – whole beam
7. Top Hat – major axis
8. Top Hat – minor axis
9. Divergence

This is the same order as listed in sections 3.1.15 through 3.1.19 below under individual results properties (also the same order as displayed in the LBA-PC Results Window). All results values will be loaded into the array all the time. Results not enabled in the LBA-PC will be zero. Note there are three sets of Gauss Fit and Top Hat results. Either the whole beam section, or the major and minor sections will contain valid results depending on how the LBA-PC is configured.

9.3.1.17 Quantitative Results

These properties provide individual Quantitative LBA-PC results. For more information, see chapter 6 in the LBA-PC Operator's Manual.

Property Name	LBA-PC Result
QuantFrameTotal	Total
QuantApertureFrac	% in Aperture

QuantPeak	Peak
QuantValley	Min
QuantPeakLocX	Peak Loc X
QuantPeakLocY	Peak Loc Y
QuantCentroidX	Centroid X
QuantCentroidY	Centroid Y
QuantRadius	
QuantBeamWidthX	Width X (Width Major)
QuantBeamWidthY	Width X (Width Minor)
QuantDiameter	Diameter

Note the QuantRadius property. This is a new result not displayed by LBA-PC. This result is the distance from the Origin to the Centroid. Since the centroid is already relative to the origin this result is defined as:

$$Radius = \sqrt{\left(C_x^{\,2} \times C_y^{\,2}\right)}$$

The Origin is specified in the Display dialog in the LBA-PC. See section 3.2.7.4 in the LBA-PC User's Manual for more information. Statistical results for QuantRadius are also provided in the Statistics property array.

9.3.1.18 Elliptical Results

These properties provide individual Elliptical beam LBA-PC results. For more information, see chapter 6 in the LBA-PC Operator's Manual.

Property Name	LBA-PC Result
EllipRotation	Rotation
EllipRoundness	Roundness

9.3.1.19 Gauss Fit Results

These properties provide individual Gauss Fit LBA-PC results. For more information, see chapter 6 in the LBA-PC Operator's Manual.

Property Name	LBA-PC Result

GaussWholeCentroidX	Centroid X
GaussWholeCentroidY	Centroid Y
GaussWholeWidthX	Width X
GaussWholeWidthY	Width Y
GaussWholeHeight	Height
GaussWholeDeviation	Deviation
GaussWholeCorrelation	Correlation
GaussMajorCentroid	Centroid X
GaussMajorWidth	Width X
GaussMajorHeight	Height X
GaussMajorDeviation	Deviation X
GaussMajorCorrelation	Correlation X
GaussMinorCentroid	Centroid Y
GaussMinorWidth	Width Y
GaussMinorHeight	Height Y
GaussMinorDeviation	Deviation Y
GaussMinorCorrelation	Correlation Y

9.3.1.20 Top Hat Results

These properties provide individual Top Hat LBA-PC results. For more information, see chapter 6 in the LBA-PC Operator's Manual.

Property Name	LBA-PC Result
TophatWholeMean	Mean
TophatWholeStdDev	StdDev
TophatWholeSDMean	SD/Mean
TophatWholeMin	Min
TophatWholeMax	Max
TophatMajorMean	Mean Major
TophatMajorStdDev	StdDev Major
TophatMajorSDMean	SD/Mean Major

TophatMajorMin	Min Major
TophatMajorMax	Max Major
TophatMinorMean	Mean Minor
TophatMinorStdDev	StdDev Minor
TophatMinorSDMean	SD/Mean Minor
TophatMinorMin	Min Minor
TophatMinorMax	Max Minor
TophatEffectiveArea	Factor
TophatEffectiveDiameter	Effective Area
TophatFactor	Effective Diam

9.3.1.21 Divergence Results

These properties provide individual Divergence Fit LBA-PC results. For more information, see chapter 6 in the LBA-PC Operator's Manual.

Property Name	LBA-PC Result
DivergenceX	Divergence X
DivergenceY	Divergence Y

9.3.1.22 Statistics Results

The Statistics property provides all of the LBA-PC statistical results in a two-dimensional array of doubles packaged as a Variant. Each row of the array contains the statistical results for a particular LBA-PC result. For each row, the columns contain the Mean, Standard Deviation, Minimum, and Maximum.

The results are loaded into the array in the following order:

1. Quantitative
2. Elliptical
3. Gauss Fit – whole beam
4. Gauss Fit – major axis
5. Gauss Fit – minor axis
6. Top Hat – whole beam
7. Top Hat – major axis

8. Top Hat – minor axis
9. Divergence

This is the same order as listed in sections 3.1.15 through 3.1.19 above under individual results properties (also the same order as displayed in the LBA-PC Results Window).

The leftmost index is identical to the index used to access the Results property. The rightmost index is defined as follows:

0	Mean
1	Standard Deviation
2	Minimum
3	Maximum

All results values will be loaded into the array all the time. Results not enabled in the LBA-PC will be zero. Note there are three sets of Gauss Fit and Top Hat results. Either the whole beam section or the major and minor sections will contain valid results depending on how the LBA-PC is configured.

9.3.1.23 Pass/Fail Results

The PassFailFlag and PassFail properties provide all of the LBA-PC pass/fail test results.

The PassFailFlag is a combination of all the individual pass/fail results. The value of PassFailFlag is defined as follows:

Fail	Some test failed
No test	No individual test enabled
Pass	All tests passed

The PassFail property provides individual pass/fail results in a one-dimensional array of integers packaged as a Variant. The pass/fail results are loaded into the array in the following order:

1. Quantitative

- There is no test for Peak Location X or Y. The value of both of these flags is always zero.
- There is no test for Radius so the flag is always zero.

2. Elliptical
3. Gauss Fit – whole beam
4. Gauss Fit – major axis
5. Gauss Fit – minor axis
6. Top Hat – whole beam
7. Top Hat – major axis

8. Top Hat – minor axis
9. Divergence

This is the same order as listed in sections 3.1.15 through 3.1.19 above under individual results properties.

Each 'flag' will contain one of the following values:

-1	Fail
0	No Test
1	Pass

All results values will be loaded into the array all the time. Results not enabled in the LBA-PC will be zero. Note there are three sets of Gauss Fit and Top Hat results. Either the whole beam section, or the major and minor sections will contain valid results depending on how the LBA-PC is configured.

9.3.2 Methods

9.3.2.1 LoadConfig

This method causes the LBA-PC to load the specified configuration file. This method takes a single parameter that is the file name of the LBA-PC configuration file you wish to be loaded. The file name must contain the full path and file name to the LBA-PC configuration file.

You cannot load a configuration while the LBA-PC is collecting frames, during Ultracal, or during Auto Exposure.

Be very sure the specified file name is a valid, accessible LBA-PC configuration file. There are many reasons why the LoadConfig may fail, most of which cause the LBA-PC to display a message on screen. If LBA-PC displays a message, this method will not return until you respond to the message.

Reasons LoadConfig may fail and LBA-PC display an error message:

- The file does not exist
- The file does not contain a valid LBA-PC configuration

This method returns the following:

-1	The LBA-PC is not available
0	OK
1	LBA-PC is collecting frames of data
2	File path name is too long
3	Load configuration error

9.3.2.2 Open

This method initiates communication between the LBA-PC ActiveX control and LBA-PC. You must call this method, or the OpenIndex method, before calling any other method or accessing any of the properties. If you do not call this method, then all the properties will be zero, methods will have no effect, and no events will fire.

The first caller to Open will connect to the first available LBA-PC application, the next callers will connect to the second LBA-PC, etc.

If you want to specify the LBA-PC application, then use the AppInfo property and call the OpenIndex method.

This method returns the following:

-1	The LBA-PC is not available
0	OK
1	Other initialization error

9.3.2.3 OpenIndex

This method initiates communication between the LBA-PC ActiveX control and LBA-PC. You must call this method, or the Open method, before calling any other method or accessing any of the properties. If you do not call this method, then all the properties will be zero, methods will have no effect, and no events will fire.

OpenIndex takes one parameter, which is the index of the application you want to connect to. The AppInfo property can be used to determine which application to connect to.

If you do not care which LBA-PC application you connect to, or have only one LBA-PC, then call the Open method.

-1	The LBA-PC is not available
0	OK
1	Other initialization error

9.3.2.4 Start

This method is identical to clicking Start! on the LBA-PC. This method has no effect if the LBA-PC is already collecting frames of data.

If Ultracal is not complete, the LBA-PC cannot start. If there is any other problem, the LBA-PC will not start and will display an error message on the LBA-PC display.

This method returns the following:

-1	The LBA-PC is not available
0	OK
1	Load configuration error

9.3.2.5 Stop

This method is identical to clicking Stop! on the LBA-PC. This method has no effect if the LBA-PC is stopped. This method immediately cancels the Ultracal operation. Any previous Ultracal is retained.

9.3.2.6 Ultracal

This method is identical to clicking Ultracal! on the LBA-PC. This method has no effect if a previous Ultracal operation is not complete.

If the LBA-PC is collecting frames of data the Ultracal cannot start. If there is any other problem, the Ultracal will not start and the LBA-PC will display an error message on the LBA-PC display.

This method returns the following:

-1	The LBA-PC is not available
0	OK
1	LBA-PC is collecting frames of data

The Ultracal operation runs for unknown amount of time depending on the camera and the LBA-PC configuration. Poll the OperationComplete property or respond to the OnOperationComplete event to determine when the Ultracal operation is complete.

9.3.2.7 Auto Exposure

This method is identical to clicking AutoExposure! on the LBA-PC. This method has no effect if a previous Auto Exposure operation is not complete.

If the LBA-PC is collecting frames of data the Auto Exposure cannot start. If there is any other problem, the Auto Exposure will not start and the LBA-PC will display an error message on the LBA-PC display.

This method returns the following:

-1	The LBA-PC is not available
0	OK
1	LBA-PC is collecting frames of data

The Auto Exposure operation runs for unknown amount of time depending on the camera and the LBA-PC configuration. Poll the OperationComplete property or respond to the OnOperationComplete event to determine when the Auto Exposure operation is complete.

9.3.3 Events

All the events can fire each time the LBA-PC collects a new frame of data. If you are still processing an event when another frame is collected then the new event is not fired. This is especially true when using LabVIEW.

9.3.3.1 OnNewFrame

This is a generic event fired each time the LBA-PC collects a new frame of data. You can read any desired property values while processing this event. During this event you are guaranteed all properties correspond to the same frame of data. After return from this event property values will change.

Please note, LBA-PC does not collect data when minimized and will not send OnNewFrame events while minimized.

During an event, LabVIEW records the event in a queue then returns. Below is a table of various ways to use this event.

LBA-PC Capture Mode	HoldNewFrame	Discussion
Single Shot	N/A	The LBA-PC stops after collecting one frame. Property values will not change until the LBA-PC receives another Start command.
Continuous	FALSE	The LBA-PC will continuously update property values. By the time a VI can read property values after the OnNewFrame event, the values have changed. Use this configuration if you do not care which frame the properties relate to.
Continuous	TRUE	The LBA-PC will set property values that correspond to the same frame of data. These values will remain until you reset NewFrame to FALSE.

OnNewFrame.vi contains an example of reading property values after receiving an OnNewFrame event. All example VIs are packaged in LbapcActiveX.llb, which can be found in the "ActiveX\Examples\LabVIEW" directory under the LBA-PC installation directory.

In Visual Basic you can read any desired properties during this event. All properties correspond to the same frame of data. After return from this event property values will change.

9.3.3.2 OnOperationComplete

This event fires when Ultracal is finished or the LBA-PC is stopped because Statistics Frames or Time has expired. This event passes an integer bit flag as a parameter. This bit flag is identical to the OperationComplete property and is defined as follows.

Ultracal complete 0x0001

Auto Exposure complete 0x0002

In LabVIEW, the parameter data is part of the Event Data cluster output from the Wait On ActiveX Event VI. Unbundle the Event Data, index the ParamData array, and convert the result using the 'Variant To Data' VI. Ultracal.vi contains an example of calling the Ultracal method and

responding to the OnOperationComplete event. Example VI's are packaged in LbapcActiveX.llb, which can be found in the "ActiveX\Examples\LabVIEW" directory under the LBA-PC installation directory.

9.4 DCOM

ActiveX is based on Component Object Model (COM) technology. DCOM, Distributed COM, extends COM to support communication among objects on different computers—on a local area network (LAN), a wide area network (WAN), or even the Internet.

The LBA-PC ActiveX server supports DCOM. The LBA-PC ActiveX server always runs on the LBA-PC computer and can easily be configured for local or remote access. Properties, methods, and events are the same as described above, whether local or remote.

Local access is always the default. When LBA-PC is installed, the LBA-PC ActiveX server is automatically registered for local access.

9.4.1 Remote Access

9.4.1.1 Server (LBA-PC) Computer

To enable remote access to the LBA-PC computer, follow the steps in the section below for your operating system.

9.4.1.1.1 Windows 2000

1. Start DCOMCNFG. From the Start menu select Run…, type dcomcnfg and click OK.
2. Enable DCOM. On the Default Properties tab, select the Enable Distributed COM on this computer check box.
3. Configure LBA-PC ActiveX server. On the Applications tab, scroll down until you see LbapcActiveX EXE. Click on LbapcActiveX EXE then click the Properties… button. On the Identity tab, select the Interactive user radio button.
4. Configure access from the remote computer. There are two ways to configure access to the LBA-PC ActiveX server:
    i. Default Security. Changing the default security will affect all DCOM applications. From the main **DCOMCNFG** window, click on the **Default Security** tab. Edit the **Default Access Permissions** and **Default Launch Permissions** to allow access from the remote computer.
    ii. Application Security. From the **LbapcActiveX EXE** properties, click on the **Security** tab. Enable and edit the custom access and launch permissions to allow access from the remote computer.

9.4.1.1.2 Windows XP

1. Start DCOMCNFG. From the Start menu select Run…, type dcomcnfg and click OK.

2. Enable DCOM. Click the plus (+) symbol next to Component Services then the plus symbol next to Computers. Right click on My Computer and select Properties. On the Default Properties tab select the Enable Distributed COM on this computer check box. Click OK.
3. Configure LBA-PC ActiveX server. Click the plus (+) symbol next to My Computer then the plus symbol next to DCOM Config. Scroll down until you find LbapcActiveX EXE. Right click on LbapcActiveX EXE and select Properties. On the Identity tab, select the Interactive user radio button. Click OK.
4. Configure access from the remote (client) computer. There are two ways to allow access from the client computer:
    i. Default Security. Changing the default security will affect all DCOM applications. From the **My Computer** | **Properties** window, click on the **Default COM Security** tab. Edit the **Access Permissions** and **Launch Permissions** to allow access from the remote computer.
    ii. Application Security. From the **LbapcActiveX EXE** | **Properties** window, click on the **Security** tab. Enable and edit the custom access and launch permissions to allow access from the remote computer.

9.4.1.2 Client (Application) Computer

To enable remote access from the application computer, follow the steps in the section below for your operating system.

9.4.1.2.1 Windows 2000

1. Copy the LBA-PC ActiveX server. Place a copy of the files LbapcX.exe and LbapcX.tlb on your application computer. These files can be found in the LBA-PC\ActiveX directory of the installation CD or the ActiveX subdirectory under the LBA-PC installation directory on the LBA-PC computer.
2. Register the LBA-PC ActiveX server. From the directory where you copied the files, run LbapcX.exe. The LBA-PC ActiveX server automatically registers itself then stops.
3. Start DCOMCNFG. From the Start menu select Run…, type dcomcnfg and click OK.
4. Enable DCOM. On the Default Properties tab select the Enable Distributed COM on this computer check box.

9.4.1.2.2 Windows XP

1. Copy the LBA-PC ActiveX server. Place a copy of the files LbapcX.exe and LbapcX.tlb on your application computer. These files can be found in the LBA-PC\ActiveX directory of the installation CD or the ActiveX subdirectory under the LBA-PC installation directory on the LBA-PC computer.
2. Register the LBA-PC ActiveX server. From the directory where you copied the files, run LbapcX.exe. The LBA-PC ActiveX server automatically registers itself then stops.
3. Start DCOMCNFG. From the Start menu select Run…, type dcomcnfg and click OK.

4. Enable DCOM. Click the plus (+) symbol next to Component Services then the plus symbol next to Computers. Right click on My Computer and select Properties. On the Default Properties tab select the Enable Distributed COM on this computer check box. Click OK.

9.4.1.2.3 Automatic Remote Access

Automatic remote access means that when you create a LBA-PC ActiveX server object on the application computer, DCOM automatically creates the object on the LBA-PC computer then manages communication as if the object were on the application computer.

To enable automatic remote access you must specify the location of the LBA-PC computer from the application computer.

9.4.1.2.3.1 Windows 2000

1. Start DCOMCNFG. From the **Start** menu select **Run...**, type **dcomcnfg** and click **OK**.
2. Configure the client computer for automatic remote access. On the **Applications** tab, scroll down until you see **LbapcActiveX EXE**. Click on **LbapcActiveX EXE** then click the **Properties...** button. Click on the **Location** tab. Unselect the **Run application on this computer** check box. Select the **Run application on the following computer**: check box. Type in the name of the LBA-PC computer or click **Browse...** to browse the available network. Click **OK**.

9.4.1.2.3.2 Windows XP

1. Start DCOMCNFG. From the **Start** menu select **Run...**, type **dcomcnfg** and click **OK**.
2. Configure the client computer for automatic remote access. Click the plus (+) symbol next to **Component Services**, then the plus symbol next to My Computer, then the plus symbol next to **DCOM Config**. Scroll down until you find **LbapcActiveX EXE**. Right click on **LbapcActiveX EXE** and select **Properties**. Click on the **Location** tab. Unselect the **Run application on this computer** check box. Select the **Run application on the following computer**: check box. Type in the name of the LBA-PC computer or click **Browse...** to browse the available network. Click **OK**.

9.4.1.2.4 Programmatic Remote Access

In Visual Basic, you can use the CreateObject function to create an object and specify the remote computer. See the Visual Basic documentation for more information.

In LabVIEW, the **Automation Open** VI contains a **Machine Name** input terminal where you can specify the remote computer. See the LabVIEW documentation for more information.

9.4.2 If you have a problem

- Start simple. Don't try to do everything in the first shot. Start with a test application that simply creates a LBA-PC ActiveX server object. On the LBA-PC computer you will briefly see a small window appear then disappear when the LBA-PC ActiveX server object is created.
- Verify all the DCOM settings on both computers. Make sure you check both the default settings and the LBA-PC ActiveX server specific settings.
- Reboot both computers after configuring DCOM on each computer.
- Minimize network problems. Remove all network protocols from both computers except one and try again.

*Note: The **Default Protocols** tab in **DCOMCNFG** appear to be only guidelines. Network protocols can still cause DCOM problems even if they are removed from the **Default Protocols** list. You must remove the protocol from your network connection.*

- Use Microsoft resources. Search Microsoft articles and knowledge base for an error code or error message. The Microsoft Developer Network web site, msdn.microsoft.com, contains a wealth of information for developers.
- Use National Instruments resources. The NI Developer Zone contains articles, examples, and a knowledge base about using ActiveX with LabVIEW.
- Search the news groups. There are many news groups devoted to COM/DCOM, OLE, ActiveX, etc. You can use www.google.com to search for these news groups or see if someone had just the same problem in the past.
- We will be happy to help in any way we can especially if the LBA-PC ActiveX server or a supplied example is misbehaving or not operating as described in this document. However, DCOM introduces so many variables that are beyond our control - especially related to protocols, connections, security, timeouts, etc. – so that we may be of limited help with your particular implementation. The list of techniques and resources above is where we go when you call…

Chapter 10 REMOTE GPIB OPERATION

10.1 Introduction

The LBA-PC can be controlled as a remote device via GPIB. For the most part, communications between the LBA-PC and the host controller will follow the data format and coding protocols outlined in the IEEE 488.1 and 488.2 standards.

This manual will not attempt to fully describe the nuances of the GPIB bus operation nor to convey fully the operation of the IEEE 488.1 and 488.2 protocols. If you are a first time user of the IEEE 488 command structure, we recommend that you obtain and review a copy of the applicable IEEE standards. Other excellent sources of information are the user manual provided with your National Instruments GPIB board and the "Tutorial Description of the HP-IB" published by Hewlett Packard.

10.2 Hardware and Software Requirements

The LBA-PC is a 32-bit application that runs only under Windows 2000 and Windows XP. The LBA-PC remote works only with National Instruments GPIB boards and corresponding software. The LBA-PC has been tested with NI-488.2M software v2.1. The National Instruments NI-488.2M device driver for Windows 2000 and XP supports the following National Instruments GPIB boards:

- AT-GPIB/TNT (PnP)
- AT-GPIB/TNT
- PCI-GPIB
- PCI-GPIB+
- PCMCIA-GPIB
- PCMCIA-GPIB+

If you have an older board you may be able to obtain an upgrade through National Instruments. Contact National Instruments for more information. Updates of the software are available on their web site at www.ni.com.

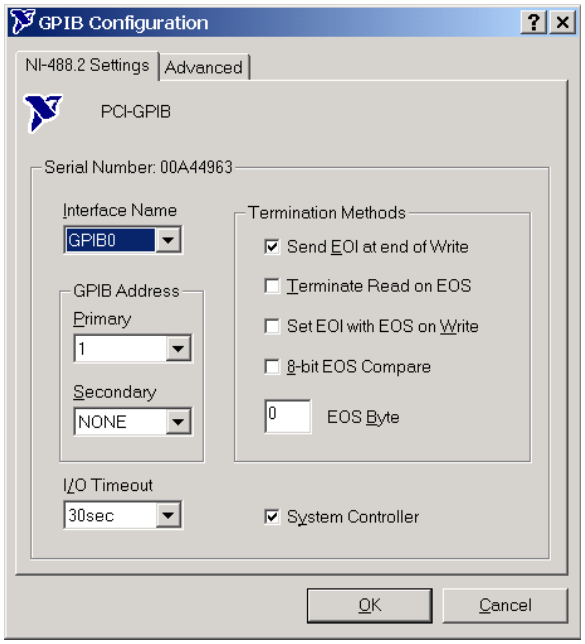
10.3 Remote GPIB Setup

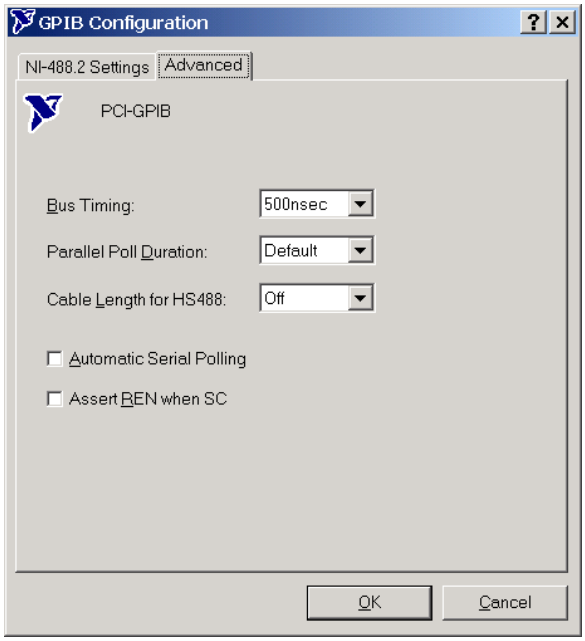
LBA-PC uses the interface name "GPIB0" and expects "Send EOI at end of Write" for all communications. To configure the NI-488.2M software for use with LBA-PC, follow these steps:

1. Click on **Start | Programs | National Instruments | NI-488.2 | Explore GPIB.**
2. **Under My System, Devices and Interfaces**, right-click on **GPIB0** and select **Properties...**
3. Set the **Primary** and **Secondary** drop-down boxes to set the GPIB address to be used by the LBA-PC.
4. Click on the **Send EOI at end of Write** button and make sure all other buttons in the **Termination Methods** section are clear.

5. Click on the **Advanced** tab, make sure that **Automatic Serial Polling** is not checked.
6. Click OK.

NOTE: It is possible for the LBA-PC to generate many service requests per second and the NI-488.2M default is to queue service requests. For these reasons we suggest you disable Automatic Serial Polling on both the LBA-PC and the host controller.





10.4 Command Formats and Responses

Commands to the LBA-PC will not normally generate a response back to the host controller, unless the command:

- Changes remote/local mode
- Is a query
- Initiates an operation that produces results
- Generates an error

10.4.1 IEEE 488.1 Command Support

The LBA-PC in combination with an appropriate National Instruments GPIB board conforms to the IEEE 488.1 standard according to the following Subset Codes:

SH1, AH1, T6, L4, SR1, RL2, PP0, DC1, DT0, E2, C0

These Subset Codes are defined in the IEEE 488.1 standard and describe interface capabilities of the LBA-PC.

The following multiple line interface message commands are supported by the LBA-PC:

GTL	-	Go To Local (0x01). When the LBA-PC detects the GTL message it returns to local command mode.
LLO	-	Local Lockout (0x11). When the LBA-PC detects the LLO message it enters what is called the lockout state. This is equivalent to entering the operator password in the Options | Password menu item. While in the lockout state access is denied to many of the LBA-PC menu items. When the LBA-PC exits the lockout state access to all menu items is restored.
MLA	-	My Listen Address (0x20 to 0x3e).
MSA	-	My Secondary Address (0x60 to 0x7e).
MTA	-	My Talk Address (0x40 to 0x5e).
PPC	-	Parallel Poll Configure (0x05). Handled by GPIB board and NI-488.2M.
PPD	-	Parallel Poll Disable (0x70 to 0x7e). Handled by GPIB board and NI-488.2M.
PPE	-	Parallel Poll Disable (0x60 to 0x6e). Handled by GPIB board and NI-488.2M.
PPU	-	Parallel Poll Unconfigure (0x15). Handled by GPIB board and NI-488.2M.
SPD	-	Serial Poll Disable (0x19).
SPE	-	Serial Poll Enable (0x18).
UN	-	Unlisten (0x3f).
UNT	-	Untalk (0x5f).

The following IEEE 488.1 commands are not supported:

DCL, GET, SDC, TCT

10.4.2 IEEE 488.2 Common Commands

The following IEEE 488.2 common commands are supported by the LBA-PC.

*IDN?	-	Identification Query
*RST	-	Reset
*CLS	-	Clear Status Registers
*ESE	-	Event Status Enable Write
*ESE?	-	Event Status Enable Query
*ESR?	-	Event Status Register Query
*SRE	-	Service Request Enable Write
*SRE?	-	Service Request Enable Query
*STB?	-	Status Byte Register Query

All other IEEE 488.2 common commands are not recognized by the LBA-PC and will return a Command Error.

10.4.3 LBA-PC Command and Data Formats

The LBA-PC does not support the IEEE 488.2 specification of sending multiple commands separated by semicolons. Each command must be sent separately and terminated by asserting the EOI line with the last byte sent.

The following are some typical formats for command and response transmissions:

cmd:	*CCC(^END)
cmd:	*CCC?(^END)
cmd:	*CCC _ key=value(^END)
cmd:	*CCC _ key=value;key=value;…;key=value(^END)
rsp:	CCC _ key=value;key=value;…;key=value;;(^END)
rsp:	CCC _ FrameNumber=f;#dn..n (DAB)…(DAB)(^END)

Where:

*	=	Precedes a 488.2 common command
:	=	Precedes a LBA-PC command
CCC	=	Three character command code, case is ignored
?	=	Query character to illicit a response
_	=	ASCII SPACE character (0x20)
key	=	Command dependent parameter

value = Value assigned to key

(DAB) = 8 bit data byte in binary format

(^END) = Indicates that EOI is asserted with the last byte sent.

10.4.4 Establishing Remote Control

Upon starting execution, the LBA-PC initializes itself in Local Mode.

The LBA-PC enters Remote Mode when it receives a :REM command or is addressed to listen when the REN line is true. The LBA-PC responds with REM when it receives the :REM command. There is no response when the REN line is used to enter Remote Mode.

The LBA-PC enters Local Mode when it receives the :LOC command or the REN line is false. The LBA-PC responds with LOC when it receives the :LOC command. There is no response when the REN line is used to enter Local Mode. In Local Mode the LBA-PC receives and responds to remote commands.

The LBA-PC automatically enters what is called the lockout state when going from Local to Remote Mode. This is equivalent to entering the operator password in the Options | Password menu item. While in the lockout state, access is denied to many of the LBA-PC menu items. The LBA-PC automatically exits the lockout state when returning to Local Mode. You can override the lockout state by sending the PSW command or by selecting Options | Password and entering the operator password.

10.5 Configuration Commands

Configuration commands allow you to do the following:

- Restore or Save configuration files
- Set or query all or part of a particular LBA-PC configuration

10.5.1 Restore and Save Configuration Files

10.5.1.1 LDC - Restore Config…

To restore a LBA-PC configuration stored on disk, you must send the LDC command along with an optional parameter that identifies the configuration file name. This command is identical to selecting the File | Restore Config menu item, entering the configuration file name, and clicking OK.

The file name is optional and is a string describing the drive, directory, file name, and extension. If no drive or directory is specified then the current Windows drive or directory is used. In Windows, the current drive and directory can be changed at any time by another program, some internal operation, or some user action. This is probably not what you want. We very strongly recommend that you always specify the drive and directory. If no extension is specified then .CFG is used.

If the file name is not specified then the current value from the last previous restore File | Restore Config., LDC command, File | Save Config., or SDC command is used. The default configuration file name can be retrieved with the LDC? command.

Note that the backslash character, "\", has special meaning known as an escape sequence. To specify a single backslash you must send two. For example*, "c:||spiricon||lba300pc||config.cfg" is interpreted by the LBA-PC as, "c:|spiricon|lba300pc|config.cfg".* Although other escape sequences are recognized there is no reason to ever use them with LBA-PC.

The following example describes how to restore the LBA-PC configuration from the file c:|spiricon|cohu4800.cfg.

Host sends

:LDC ConfigFileName=c:||spiricon||cohu4800.cfg(^END)

10.5.1.2 SDC - Save Config…

To save the current LBA-PC configuration to a file on disk, you must send the SDC along with any optional parameter that identifies the configuration file name. This command is identical to selecting the File | Save Config menu item, entering the configuration file name, and clicking OK.

The file name is optional and is a string describing the drive, directory, file name, and extension. If no drive or directory is specified then the current Windows drive or directory is used. In Windows, the current drive and directory can be changed at any time by another program, some internal operation, or some user action. This is probably not what you want. We very strongly recommend that you always specify the drive and directory. If no extension is specified then .CFG is used.

If the file name is not specified then the current value from the last previous restore File | Restore Config, LDC command, File | Save Config, or SDC command is used. The default configuration file name can be retrieved with the SDC? command.

Note that the backslash character, "\", has special meaning known as an escape sequence. To specify a single backslash you must send two. For example, *"c:||spiricon||lba300pc||config.cfg" is interpreted by the LBA-PC as, "c:|spiricon|lba300pc|config.cfg".* Although other escape sequences are recognized there is no reason to ever use them with LBA-PC.

The following example describes how to save the current LBA-PC configuration to the file c:|spiricon|remote.cfg.

Host sends

:SDC ConfigFileName=c:||spiricon||remote.cfg(^END)

10.5.2 Configuration Commands

Configuration commands allow you to change the current configuration of the LBA-PC. These commands are modeled after the dialog boxes displayed on the screen after selecting some items in the File menu, and all the items in the Options and Pass/Fail menus.

Commands to set a configuration have the following format:

:CCC key=value;key=value;…;key=value;key=value(^END)

Where:

:	=	ASCII colon character (0x3A)
CCC	=	three character command code (case is ignored) followed by a space
Key	=	ASCII text code for which parameter to set (case ignored)
=	=	ASCII equal sign character (0x3D)
value	=	value to be assigned to the parameter specified by key.

The particular parameter type, format, and allowable range are dependent on which key is being set.

;	=	ASCII semi-colon character (0x3B)

In this document "key=value" is collectively called a parameter. Parameters can occur in any order.

Range checking is performed on all values in "key=value" for each transmitted command. A **Range Error** occurs if any value is invalid or out of range, the entire command is then ignored.

The following is a list of LBA-PC configuration command data types used for 'value':

Type	Description
L	Selection. ASCII numeric value corresponding to the desired selection. All selections start with a base value of zero.

I	Integer. ASCII numeric value in integer format.
B	Boolean. ASCII numeric integer value. 0 = false. 1 = true.
F	Fixed/Floating. ASCII numeric value in fixed or floating point notation.
S	String. Series of ASCII characters. Note that the backslash, "\", has special meaning in strings known as an escape sequence. To specify a single backslash, you must send two. *For example: "c:||spiricon||lba300pc||lbapc.cfg" is interpreted as "c:|spiricon|lba300pc|lbapc.cfg".* Although other escape sequences are recognized there is no reason ever to use them with LBA-PC.
T	Time. ASCII numeric integer values in the form [[HHH:]MM:]SS.
D	Date. ASCII numeric integer values in the form MM/DD/YY.

You can obtain the current settings associated with any configuration command by sending the command followed by the query character, "?". Any parameters that are part of a query command is a command error, unless they are specifically allowed in the command description.

Configuration query commands return all of the keys for the specified configuration in the following format:

CCC key=value;key=value;…;key=value;key=value;(^END)

Other query commands respond in ways that are specific to a particular command. See the individual command listings in Appendix A for details.

The following example illustrates the process for setting the Crosshair Location Mode to Peak.

Host sends

:DIS Crosshair=3(^END)

The following example illustrates the process for querying the current Aperture configuration.

Host sends

:APT?(^END)

LBA-PC sends

APT

DrawShape=1;

CenterXLoc=1.600e+01;

CenterYLoc=1.500e+01;

Major=8.000e+00;

Minor=7.500E+00;

Rotation=0;

DisplayShape=0;

AutoAperture=1;

10.6 Transfer Commands

Transfer commands allow you to do the following:

- Download raw data (whole frames or data at the cursors)
- Read, write, upload, or download data files
- Set or query conditions associated with a frame
- Download computational results
- Download pass/fail results
- Log data or results to the host

The LBA-PC uses the IEEE 488.2 Definite Length Arbitrary Block Response Data specification to send and receive binary data. This specification has the form:

#nd..d(DAB)…(DAB)

Where:

#	=	ASCII pound symbol (0x23)
n	=	ASCII decimal digit ranging from 1 to 9. This value specifies the number of digit elements, d..d, that follow.
d..d	=	ASCII decimal integer that specifies the number of data bytes that follow.
(DAB)	=	8-bit data byte.

The LBA-PC also uses a modified form of the specification that has the form:

#nd..d(DAW)…(DAW)

Where:

#	=	ASCII pound symbol (0x23)
n	=	ASCII decimal digit ranging from 1 to 9. This value specifies the number of digit elements, d..d, that follow.
d..d	=	ASCII decimal integer that specifies the number of data words that follow.
(DAW)	=	Data Word. Two 8-bit data bytes, low byte followed by high byte.

The second form is used to emphasize the fact that each pixel is a 16-bit value.

10.6.1 Transferring Raw Data

You can download a frame of data from the LBA-PC. If you do not specify a specific frame then data from the current frame is transferred. Data frames are always transferred as raw data. Data frames contain no information about conditions that created the data. To obtain other information regarding the conditions under which the frame was created (i.e. pixel scale, energy calibration, capture resolution, etc.) you will need to also transfer the Frame Status data (see A.5.4.7 FST). If you want

quantitative results, you will also have to retrieve that separately (see A.5.4.17 RDR?). If you wish to associate this information with a data frame, be sure to specify the same frame number for the data and status/results.

Three commands allow you to download raw data or data at the cursors from any frame including the reference and gain frames. These commands are:

RCC? - Download data in the column at the cursor

RCR? - Download data in the row at the cursor

RDD? - Download a frame of data

The LBA-PC may also be configured to automatically send a RDD? response each time a new frame of data is acquired (see A.5.4.16 RDD?).

10.6.1.1 RCC?, RCR? - Read Cursor Transfer

To download data at the cursors from the LBA-PC, you must send the RCC? or RCR? command with optional parameters that identify which frame and column or row, as appropriate, you are requesting to transfer.

The frame parameter is optional and is numbered from -1 to n. 'n' is the number of frames in the frame buffer. Frame -1 is the Gain Frame, 0 is the Reference frame, and frames 1 to n are data captured in the frame buffer. If you do not send the frame number parameter then the current frame is used.

The column or row, counted from the upper left corner of the beam window, parameter is optional and is numbered from 1 to n. 'n' is the frame width or frame height, respectively. If you do not send a column or row parameter then the current cursor location is used.

The data at the cursors is sent as a modified IEEE 488.2 Definite Length Arbitrary Block Response Data. The number of bytes in a column or row is two times the number of pixels. For example, a row of a 128 X 120 frame consists of 256 bytes and a column has 240 bytes. Each pixel is a sixteen-bit two's complement fixed point value having one of the following forms:

siiiiiii iffffffff	LBA-300PC	-256 to 255.9921875
siiiiiii iiiffffff	LBA-400PC	-1024 to 1023.96875
siiiiiii iiiiifff	LBA-500PC	-4096 to 4095.875
siiiiiii iffffffff	LBA-708PC	-256 to 255.9921875
siiiiiii iiiffffff	LBA-710PC	-1024 to 1023.96875
siiiiiii iiiiifff	LBA-712PC	-4096 to 4095.875
siiiiiii iiiiiiif	LBA-712PC	-16384 to 16383.5

Where:

s = sign bit

i = integer

f = fraction

Use the :FST? command to determine the specific fixed point format of pixels in a frame. The PixelBits parameter specifies the number of integer bits. The PixelBitsFraction parameter specifies the number of fraction bits. To convert a sixteen bit fixed point data word to a floating point value, divide the data word by 2 raised to the power of PixelBitsFraction (128, 32, 8, or 2 for the LBA-300/708PC, LBA-400/710PC, LBA-500/712PC, or LBA-714PC respectively).

The LBA-PC responds to the query by repeating RCC or RCR followed by two parameters specifying the frame number and number of data rows or number of data columns. Next comes the definite length specification which has the form:

#nd..d(DAW)…(DAW)

Where:

#	=	ASCII pound character (0x23)
n	=	ASCII decimal digit ranging from 1 to 9. This value specifies the number of digit elements, d..d, that follow.
d..d	=	ASCII decimal integer that specifies the number of data words that follow.
(DAW)	=	Data Word. Two 8-bit data bytes, low byte followed by high byte.

Column data is transmitted from the display's top to bottom and row data is transmitted from the display's left to right.

The following example describes how the host controller requests and receives column 49 in frame 3. Frame 3 is 256 X 240 so 240 data words, or 480 bytes, is sent to the host.

Host sends

:RCC?

FrameNumber=3;

Column=49(^END)

LBA-PC sends

RCC

FrameNumber=3;

Column=49;

#3240(DAW)…(DAW)(^END)

The following example describes how the host controller requests and receives the row at the cursor in the current frame. The current frame is 512 X 480 so 512 data words, or 1024 bytes, is sent to the host.

Host sends

:RCR?(^END)

LBA-PC sends

RCC

FrameNumber=19;

Row=11;

#3512(DAW)…(DAW)(^END)

10.6.1.2 RDD? - Read Frame Transfer

To download a frame of data from the LBA-PC, you must send the RDD? command along with any optional parameter that identifies which frame you are requesting to transfer.

The frame parameter is optional and is numbered from -1 to n. 'n' is the number of frames in the frame buffer. Frame -1 is the Gain Frame, 0 is the Reference frame, and frames 1 to n are data captured in the frame buffer. If you do not send the frame number parameter then the current frame is used.

The frame data is sent as a modified IEEE 488.2 Definite Length Arbitrary Block Response Data. The number of bytes in a frame is two times the number of pixels. For example, a 128 X 120 frame consists of 30,720 bytes, a 256 X 240 frame consists of 122,880 bytes, etc. Each pixel is a sixteen-bit two's complement fixed point value having the form:

siiiiiii iffffffff	LBA-300PC	-256 to 255.9921875
siiiiiii iiiffffff	LBA-400PC	-1024 to 1023.96875
siiiiiii iiiiifff	LBA-500PC	-4096 to 4095.875
siiiiiii iffffffff	LBA-708PC	-256 to 255.9921875
siiiiiii iiiffffff	LBA-710PC	-1024 to 1023.96875
siiiiiii iiiiifff	LBA-712PC	-4096 to 4095.875
siiiiiii iiiiiiif	LBA-714PC	-16384 to 16383.5

Where:

s	=	sign bit
i	=	integer
f	=	fraction

Use the :FST? command to determine the specific fixed point format of pixels in a frame. The PixelBits parameter specifies the number of integer bits. The PixelBitsFraction parameter specifies the number of fraction bits. To convert a sixteen bit fixed point data word to a floating point value, divide the data word by 2 raised to the power of PixelBitsFraction (128, 32, 8, or 2 for the LBA-300/708PC, LBA-400/710PC, or LBA-500/712PC, or LBA-714PC respectively).

The LBA-PC responds to the query by repeating RDD followed by three parameters specifying the frame number, number of data columns, and number of data rows. Next comes the definite length arbitrary block response data specification, which has the form:

#nd..d(DAW)…(DAW)

Where:

#	=	ASCII pound character (0x23)
n	=	ASCII decimal digit ranging from 1 to 9. This value specifies the number of digit elements, d..d, that follow.
d..d	=	ASCII decimal integer that specifies the number of data words that follow.
(DAW)	=	Data Word. Two 8-bit data bytes, low byte followed by high byte.

The data is transmitted in a row and column sequence beginning at the display's upper left-hand corner, proceeding row by row and ending at the lower right-hand corner.

The following example describes how the host controller requests the current frame and receives the data. The received data frame has the dimensions of 64 X 60. Therefore, the LBA-PC transmits 3840 data words (pixels), or 7680 bytes to the host controller.

Host sends

:RDD?(^END)

LBA-PC sends

RDD

FrameNumber=9;

Width=64;

Height=60;

#43840(DAW)…(DAW)(^END)

The following example describes how the host controller requests and receives data in frame number 17. The LBA-PC sends the 32 X 30 frame as 960 data words or 1920 bytes.

Host sends

:RDD?

FrameNumber=17(^END)

LBA-PC sends

RDD

FrameNumber=17;

Width=32;

Height=30;

#3960(DAW)…(DAW)(^END)

10.6.2 Transferring Data Files

Four commands allow you to download, upload, read or write data files. These commands are:

FRM?	-	Download data file	(remote to host)
FRM	-	Upload data file	(host to remote)
LDD	-	File | Load… data file	(loaded @ remote)
SDD	-	File | Save As… data file	(saved @ remote)

The FRM command is used to download and upload LBA-PC data files. The transmitted data is in an internal binary form that is identical to a .LB3/4/5 data file. The format of this data is not documented. To use this command you must save and restore exactly what was received from the LBA-PC. Data downloaded with the FRM? command should be written to a file on disk with the extension .LB3/4/5. This data file can then be read by LBA-PC using the File | Load… dialog box. To upload a data file, you must send exactly the binary data received in a previous FRM? command or exactly the binary data read from a .LB3/4/5 file written by LBA-PC.

The LBA-PC may also be configured to send a FRM? response each time a new frame of data is acquired (see A.5.4.6 FRM).

The LDD and SDD commands are used to tell the LBA-PC to read and write data files on the remote computer, (the PC where the LBA-PC application is running).

10.6.2.1 FRM? - Download Data Frame

To download an LBA-PC data frame, you must send the FRM? command with an optional parameter that identifies which frame you are requesting to transfer.

The frame parameter is optional and is numbered from -1 to n. 'n' is the number of frames in the frame buffer. Frame -1 is the Gain Frame, 0 is the Reference frame, and frames 1 to n are data captured in the frame buffer. If you do not send the frame number parameter then the current frame is used.

The LBA-PC responds by repeating FRM followed by a parameter specifying the frame number. Next comes the definite length specification that has the form:

#nd..d(DAB)…(DAB)

Where:

#	=	ASCII pound character (0x23)
n	=	ASCII decimal digit ranging from 1 to 9. This value specifies the number of digit elements, d..d, that follow.
d..d	=	ASCII decimal integer that specifies the number of data words that follow.
(DAB)	=	8-bit data byte.

The following example describes how the host controller requests and receives a data file containing frame 10. The data file contains 32,768 bytes.

Host Sends

:FRM?

FrameNumber=10(^END)

LBA-PC sends

FRM

FrameNumber=10;

#532768(DAB)…(DAB)

10.6.2.2 FRM - Upload Data Frame

To upload an LBA-PC data frame, you must send the FRM command with optional parameters that identify the frame number and whether to replace an existing configuration.

The frame parameter is optional and is numbered from -1 to n. 'n' is the number of frames in the frame buffer. Frame -1 is the Gain Frame, 0 is the Reference frame, and frames 1 to n are data captured in the frame buffer. If you do not send the frame number parameter then the current frame is used.

The replace parameter is optional and is a boolean with a value of 0 or 1 (i.e., false or true). The default for the replace parameter is 0 (i.e., false).

- If the replace parameter is true and the camera type or camera resolution of the file being uploaded is different than the current configuration, then the camera type, resolution, or both are changed to match the file and the file is stored in the frame buffer. Note that the frame buffer is cleared when the camera type or camera resolution is changed.
- If the replace parameter is false and the camera type or camera resolution does not match the current LBA settings, then an execution error is reported and the file is discarded.
- If the replace parameter is true and the pixel scale of the uploaded file is different than the current configuration, then the pixel scale is set to the value in the file and the file is stored in the frame buffer.
- If the replace parameter is false and the pixel scale is different, then the pixel scale is not changed and the file is stored in the frame buffer.
- If the replace parameter is true and the energy calibration of the uploaded file is different than the current configuration, then the energy calibration is set to the value in the file and the file is stored in the frame buffer.

If the replace parameter is false and the energy calibration is different, then the energy calibration is not changed and the file is stored in the frame buffer.

NOTE: You must send exactly the binary data received in a previous FRM? command or exactly the binary data read from a .LB3/4/5 file written by LBA-PC.

The following example describes how the host uploads a data file to frame 33. Because the replace parameter is not specified the file will be stored only if the camera and camera resolution match the current configuration. The pixel scale will not be changed. The file contains 124,928 bytes.

Host sends

FRM

FrameNumber=33;

#6124928(DAB)…(DAB)(^END)

The following example describes how the host uploads a data file to frame 25. The replace parameter is specified so the camera or camera resolution will be changed if the settings in the file are different than the current configuration. The pixel scale and energy calibration will also be changed to the file value if different than the current configuration. The file contains 124,928 bytes.

Host sends

FRM

FrameNumber=25;

Replace=1;

#6124928(DAB)…(DAB)(^END)

10.6.2.3 LDD - Read Data File

To read a data file stored on the LBA-PC computer, you must send the LDD command with optional parameters identifying the frame number, start record, number of records, start frame, file name, and whether to replace an existing configuration. This command is identical to selecting the File | Load… menu item, entering the file name, start record, number of records, and start frame, and clicking OK.

The start record is optional and is numbered from 1 to n. 'n' is the number of records in the file.

The number of records is optional and is numbered from 0 to n, where 'n' is the number of records in the file. A value of 0 specifies all of the records from the start record to the end of the file. The number of records is forced to 1 when the start frame is -1 or 0.

If the start record or number of records is not specified then the value from the last File | Restore Config, LDC command, File | Load, File | Save, LDD command, or SDD command is used.

The start frame parameter is optional and is numbered from -1 to n. 'n' is the number of frames in the frame buffer. Frame -1 is the Gain Frame, 0 is the Reference frame, and frames 1 to n are data captured in the frame buffer. If you do not send the frame number parameter then the current frame is used.

The replace parameter is optional and is a boolean with a value of 0 or 1 (i.e., false or true). The default for the replace parameter is 0 (i.e., false).

- If the replace parameter is true and the camera type or camera resolution of the file being read is different than the current configuration, then the camera type, resolution, or both are changed to match the file and the file is stored in the frame buffer. Note that the frame buffer is cleared when the camera type or camera resolution are changed.
- If the replace parameter is false and the camera type or camera resolution does not match the current LBA settings, then an execution error is reported and the file is discarded.
- If the replace parameter is true and the pixel scale of the file is different than the current configuration, then the pixel scale is set to the value in the file and the file is stored in the frame buffer.

- If the replace parameter is false and the pixel scale is different, then the pixel scale is not changed and the file is stored in the frame buffer.
- If the replace parameter is true and the energy calibration of the file is different than the current configuration, then the energy calibration is set to the value in the file and the file is stored in the frame buffer.
- If the replace parameter is false and the energy calibration is different, then the energy calibration is not changed and the file is stored in the frame buffer.

The file name is optional and is a string describing the drive, directory, file name, and extension. If no drive or directory is specified then the current Windows drive or directory is used. In Windows, the current drive and directory can be changed at any time by another program, some internal operation, or some user action. This is probably not what you want. We very strongly recommend that you always specify the drive and directory. If the extension is not specified then .LB3/4/5/7 is used. If the file name is not specified then the current value from the last previous restore File | Restore Config, LDC command, File | Load, File | Save, LDD command, or SDD command is used.

Note that the backslash character, "\", has special meaning known as an escape sequence. To specify a single backslash you must send two. For example, "c:\\spiricon\\lba300pc\\data.lb3" is interpreted by the LBA-PC as "c:\spiricon\lba300pc\data.lb3". Although other escape sequences are recognized there is no reason to ever use them with the LBA-PC.

The current default values for the start record, number of records, and file name can be retrieved with the LDD? command.

The following example describes how to read all the records from a file into the frame buffer starting at frame 7.

Host sends

:LDD

FileName=c:||spiricon||lba300pc||tophat.lb3;

StartRecord=1;

NumberRecords=0;

StartFrame=7(^END)

10.6.2.4 SDD - Save Data File

To write a data file on the LBA-PC computer, you must send the SDD command with optional parameters identifying the frame number, start frame, number of frames, and file name. This command is identical to selecting the

File | Save As… menu item, entering the file name, start frame, and number of frames, and clicking OK.

The frame parameter is optional and is numbered from -1 to n. 'n' is the number of frames in the frame buffer. Frame -1 is the Gain Frame, 0 is the Reference frame, and frames 1 to n are data captured in the frame buffer. If you do not send the frame number parameter then the current frame is used.

The number of frames is optional and is numbered from 0 to n, where 'n' is the maximum number of frames in the frame buffer. A value of 0 specifies all the frames in the frame buffer. The number of frames is forced to 1 when the start frame is -1, or 0. If no number of frames is

specified then the value from the last File | Restore Config, LDC command, File | Load, File | Save, LDD command, or SDD command is used.

The file name is optional and is a string describing the drive, directory, file name, and extension. If no drive or directory is specified then the current Windows drive or directory is used. In Windows, the current drive and directory can be changed at any time by another program, some internal operation, or some user action. This is probably not what you want. We very strongly recommend that you always specify the drive and directory. If no extension is specified then .LB3/4/5/7 is used. If the file name is not specified then the current value from the last previous restore File | Restore Config, LDC command, File | Load, File | Save, LDD command, or SDD command is used.

Note that the backslash character, "\", has special meaning known as an escape sequence. To specify a single backslash you must send two. For example*: "c:||spiricon||lba300pc||data.lb3" is interpreted by the LBA-PC as "c:|spiricon|lba300pc|data.lb3"*. Although other escape sequences are recognized there is no reason ever to use them with LBA-PC.

The current default values for the start record, number of records, and file name can be retrieved with the SDD? command.

The following example describes how to write all the frames from the frame buffer into a file called tophat.lb3.

Host sends

:SDD

FileName=c:||spiricon||lba300pc||tophat.lb3;

StartFrame=1;

NumberFrames=0(^END)

10.6.2.5 RDR? - Read Results

The results displayed in the Results window can be downloaded by using the RDR? command. This query command has three optional parameters:

Labels	Text labels from left-hand column of results window
Values	Computations results from center column
Units	Applicable units from right-hand column

The Labels parameter specifies whether you want to download the text in the left-most column of the results windows. This text is a label describing the value in the center column. The Values parameter specifies you want to download the numeric values displayed in the center column of the results window. The Units parameter specifies you want to download the text in the right-most column of the results window. This text is a label describing the units that apply to the value in the center column. If more that one parameter is specified then each is sent in a separate response. If these parameters are not specified then the default is Labels=0, Values=1, Units=0.

The Labels and Values response changes when statistics is on. For the Labels response, each label displayed in the left-hand column of the results window is followed by the text "Mean, Deviation, Minimum, Maximum". The statistics Results response is all numeric values in each row displayed in the center columns of the results windows. Therefore, when statistics is on, you will receive five numeric values for each row corresponding to the current, mean, deviation, minimum, and maximum values.

The following example describes how to download the current result values displayed in the results window:

Host sends

:RDR?

(^END)

LBA-PC sends

RDR

3298655,

86.96,

1.776e+02,

2.288e+01,

1.846e+03,

1.950e+03,

1.696e+03,

1.519e+03,

3.842e+03,

3.781e+03,

3.812e+03(^END)

The following example describes how to download the current labels and units displayed in the results window.

Host sends

:RDR?

Labels=1;

Values=0;

Units=1(^END)

LBA-PC sends

RDR

Total,

% Above Clip,Peak,

Min,

Peak Loc X,

Peak Loc Y,

Centroid X,

Centroid Y,

Width X,

Width Y,

Diameter(^END)

LBA-PC sends

RDR

,%,,,um,um,um,um,um,um,um(^END)

10.6.2.6 LOG - Logging

You can configure the LBA-PC to automatically send a FRM or RDD and RDR response each time new data is acquired. Remote logging is the fastest method available to transfer new frames from the LBA-PC.

Use the File | Logging… dialog box or the LOG configuration command to specify logging new data or results to the host. If the data log file name is "FRM" or "RDD" then each time a new frame of data is acquired the LBA-PC will automatically send a response as if you had sent ":FRM?" or ":RDD?" respectively. If the results log file name is "RDR" then each time a new frame of data is acquired the LBA-PC will automatically send a response as if you had sent ":RDR?".

The LBA-PC will not capture another frame until the host reads the current logging response.

This example describes how to enable data file logging to the host controller.

Host sends

:LOG

DataLogging=1;

DataFileName=FRM(^END)

Host sends

:RUN

LBA-PC sends

FRM

FrameNumber=1;

#516384(DAB)…(DAB) (^END)

LBA-PC sends

FRM

FrameNumber=2;

#516384(DAB)…(DAB)(^END)

LBA-PC sends

FRM

FrameNumber=3;

#516384(DAB)…(DAB)(^END)

etc.

10.6.2.7 FST? - Transferring Status Information

The commands RCC, RCR, and RDD will permit you to download raw binary data. This data does not tell you under what conditions the data was acquired. More information needs to be transferred from the LBA-PC if you hope to perform an analysis of this data.

The LBA-PC takes a snapshot of existing conditions each time a frame of data is acquired. If you are downloading data from the LBA-PC, you can get a copy of the prevailing conditions that existed at the moment the data was acquired by using the FST? command.

The FST? command returns the following information about each frame:

- Frame number
- Acquisition date and time
- Which camera the frame was collected from
- Number of integer and fraction bits in raw pixel
- Pixel scale
- Pixel units
- Gamma correction factor
- Lens setting
- X and Y capture location
- X and Y capture size
- Capture resolution
- Calibration energy
- Raw frame total equivalent to calibration energy
- Energy units
- Whether the Ultracal or reference frame has been subtracted and whether gain correction has been applied.
- User comment
- Whether the frame is write protected.

The FST command allows you to change the following information about each frame:

- User comment

- Turn on/off write protection

The following example describes how to retrieve the frame status of frame number 27.

Host sends

:FST?

FrameNumber=27(^END)

LBA-PC sends

FST

FrameNumber=27;

CameraInput=0;

Date=11/24/97;

Time=03:17:55.16;

PixelBits=8;

PixelHScale=1.300e+01;

PixelVScale=1.300e+01;

PixelUnits=1;

Gamma=1.000e+00;

Lens=0;

PixelBitsFraction=7;

CaptureLocation=32,44;

CaptureSize=128,120;

CaptureResolution=2;

EnergyOfBeam=0.000e+00;

EnergyOfFrame=0.000e+00;

EnergyUnits=2;

AC=1;

RS=0;

GC=0;

CommentLine=This is a test shot;

WriteProtect=0(^END)

The following example describes how to set a frame comment and write protect frame number 52.

Host sends

:FST

FrameNumber=52;

CommentLine=This will appear in the title bar;

WriteProtect=1(^END)

10.6.3 PFS? - Pass/Fail Status

To retrieve the current pass/fail status, you must send the PFS? command.

The LBA-PC responds by repeating PFS followed by a "key=value" parameter for each value that has pass/fail testing enabled. The 'key' is an ASCII text string identical to the label displayed in the left-hand column of the results window. The 'value' is a boolean, where 0 equals fail and 1 equals pass.

The following example describes how the host controller retrieves the current pass/fail testing status. Total, Peak, Centroid X, and Centroid Y are being tested. Total passed, Peak failed, Centroid X failed, Centroid Y passed.

Host sends

:PFS?

LBA-PC sends

PFS

Total=1;

Peak=0;

Centroid X=0,

Centroid=1(^END)

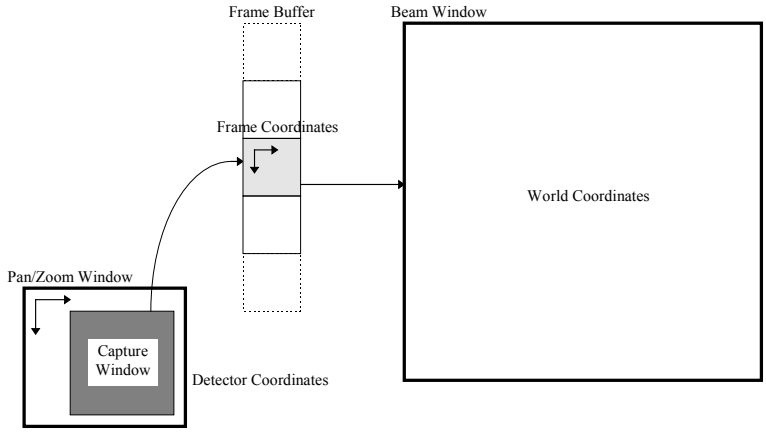
10.7 COORDINATE SYSTEMS

10.7.1 Spatial Coordinates

The visible spatial coordinate system of the LBA-PC is called world coordinates. World coordinates are used for computed centroid location and peak location, aperture location, cursor and crosshair location, and pass/fail centroid and peak locations. World coordinates are defined by the Origin Location, 'Lens' setting, and Pan Location. The world coordinates system is the only coordinate system that is used when using the LBA-PC in the local, non-remote mode.

When operating the LBA-PC remotely, you must be aware of two other coordinate systems called detector and frame coordinates. Detector coordinates are represented on the LBA-PC display by the Pan/Zoom window. Detector coordinates are used to describe the active pixels of the camera detector. Frame coordinates are used to describe the frame data stored in the frame buffer.

The figure below shows the relationship between the Pan/Zoom window, the capture window, frame data, and the Beam display window. The Pan/Zoom window represents the active area of the camera detector. The capture window, represented in the LBA-PC display by the dark gray square inside the Pan/Zoom window, represents the location and size of the area of the detector that will be digitized. The digitized data is placed in the frame buffer. Data in the frame buffer is then converted to false color or gray scale and displayed in the beam window.



Coordinate Systems

Figure 62

10.7.2 Pan/Zoom Window Detector Coordinates

Detector coordinates define locations on the camera detector. Detector coordinates are always positive integers. For a particular camera type, detector coordinates never change. The detector coordinate origin is always the upper left corner of the detector. This origin does not start at x=0, y=0, rather it relates to electronic timing of the camera. X values increase to the right and decrease to the left. Y values increase going down and decrease going up.

The Pan/Zoom window represents the boundary of active pixels on the detector. Use the PNW? command to retrieve the upper left and lower right corners describing the camera detector pan window limits.

The following example describes how to retrieve the boundaries of the camera detector and set the upper left corner of the capture window to the upper left corner of the detector.

Host sends

:PNW?(^END)

LBA-PC sends

PNW

UpperLeft=112,32;

LowerRight=744,512(^END)

Host sends

:PAN

X=112;

Y=32(^END)

Detector coordinates are used to position the origin location which in turn defines the World Coordinate system. Detector coordinates also are used to define the location of the frame data capture windwo which in turn defines the Frame Coordinate system.

10.7.2.1 DIS - Set Manual Origin Location

The Origin location can be set anywhere inside the :PNW? limits. Since the Origin location defines world coordinates, there is no way for you to associate a particular world coordinate with the manual origin location. The Origin location must be defined in terms of the detector coordinate system.

See section 9 regarding the World Coordinate system and the LBA-PC online help for more information about Origin Locations.

The following example describes how to enable the manual origin and set the manual origin location to the center of the detector. The center of the detector in this example is at (112+744)/2 and (32+512)/2.

Host sends

:DIS

Origin=0(^END)

Host sends

:PNW?(^END)

LBA-PC sends

PNW

UpperLeft=112,32;

LowerRight=744,512(^END)

Host sends

:DIS

ManualOrigin=426,272(^END)

Another technique that you can use to position the origin in manual origin mode is to move the cursors to the desired location (:CUR) and send the :ORG command which sets the manual origin to the current cursor location.

10.7.2.2 PAN - Set Capture Window Location

The PAN command specifies the upper left corner of the capture window. The entire capture window must fit inside the current pan window limits retrieved with the PNW? command.

The PAN command is affected by the current capture resolution (zoom). Use the :PAN? command to retrieve the current capture window location and resolution. The capture resolution value is coded as a power of two. A capture resolution value of 0 represents 2^0 which equals 1, a value of 1 represents 2^1 = 2, 2 represents 2^2 = 4, etc. When the capture resolution is x1, x2, x4, etc., the LBA-PC samples every pixel, every other pixel, every 4th pixel, etc. If the current frame size is 64 X 60 then the area covered by the capture window is actually 64 X 60, 128 X 120, 256 X 240, etc. To determine the actual size of the capture window, multiply the capture size by the capture resolution.

The upper left corner of the pan window must be placed on an integer multiple of the capture resolution starting from the upper left corner of the pan window limit. For example, if the left edge of the pan window limit is at 112 and the capture resolution is x8 then the left edge of the pan window must be placed at 112, 120, 128, etc. Illegal values will be truncated to the next lower integer multiple.

The following describes how to center the pan window in the detector. In this example the horizontal center of the detector is at (112+744)/2=428 and the vertical center is at (32+512)/2=272. The frame data size is 128 X 120. The capture resolution value is 1, so we must multiply the data size by 2^1=2. Therefore, the actual size of the capture window is 256 X 240. To put the capture window center at the detector center we subtract half the capture window size, 428-128=300 and 272-120=152.

Host sends

:PNW?(^END)

LBA-PC sends

PNW

UpperLeft=112,32;

LowerRight=744,512(^END)

Host sends

:PAN?(^END)

LBA-PC sends

PAN

CaptureLoc=112,32;

CaptureSize=128,120;

CaptureResolution=1(^END)

Host sends

PAN

X=300;

Y=152(^END)

The following describes how to set the pan window to the lower right corner of the detector. In this example the lower right corner of the detector is at (744, 512). The frame data size is 32 X 30. The capture resolution value is 2, so we must multiply the data size by 2^2=4. Therefore the actual size of the capture window is 128 X 120. To put the capture window in the lower right corner we subtract the capture window size from the lower right limits, 744-128=616 and 512-120=392.

Host sends

:PNW?(^END)

LBA-PC sends

PNW

UpperLeft=112,32;

LowerRight=744,512(^END)

Host sends

:PAN?(^END)

LBA-PC sends

PAN

CaptureLoc=224,64;

CaptureSize=32,30;

CaptureResolution=2(^END)

Host sends

PAN

X=616;

Y=392(^END)

10.7.3 Frame Coordinates

Frame coordinates are used for the frame data stored in the frame buffer. Frame coordinates are dependent only on the frame size. Frame coordinates are always positive with the origin in the upper left corner. Frame coordinates are specified with column and row values. Column values increase to the right and are numbered from 1 to the frame width. Row values increase going down and are numbered from 1 to the frame height.

Frame coordinates are used in the :RCC? and :RCR? commands to specify which column and row to download.

Although :RCC? and :RCR? allow you to download data from the current cursor column and row, there is no way to associate the cursor location in world coordinates (described below) with a particular data frame column or row. Download cursor column and row are intended to be useful only when the cursor is set to follow the centroid, or peak location.

See section 2.3.1.1 RCC?, RCR? - Read Cursor Transfer for additional information.

10.7.4 Beam Window World Coordinates

Most parameters that specify spatial coordinates must be in LBA-PC world coordinates. World coordinates are used for locations in the current frame as displayed in the beam window with no magnification. World coordinates are displayed for computed centroid location and peak location results, aperture location, cursor and crosshair location, and pass/fail locations. World coordinates are dependent on the frame size, capture resolution, origin location, and pixel scale. These dependency values may change from frame to frame.

World coordinates are based upon the Origin Location, which defines x=0, y=0. If the origin is set to Detector lower left, Window lower left, or manual then y values increase going up and decrease going down as viewed in the beam window. If the origin is set to Detector upper left or Window upper left then y values increase going down and decreases going up. If manual origin is enabled then negative x values are to the left and positive to the right, and y negative values are down and positive up. See the LBA-PC online help for more information about using Origin Locations.

NOTE: When the Origin Location is set to Window UL or Window LL, the World Coordinate system moves relative to the detector coordinates as the Beam Window is panned or hardware zoomed.

World coordinates are used to set the aperture center location (:APT), the manual cross-hair location (:CHR), and the manual cursor location (:CUR).

Use the WLD? command to retrieve the location of upper left and lower right corner of the current frame in world coordinates.

The following example describes how to retrieve the boundaries of the current frame then set the cursor to the center of the frame.

Host sends

:WLD?

LBA-PC sends

WLD
UpperLeft=0.000e+00,0.000e+00;
LowerRight=6.630e+03,6.214e+03

Host sends

:CUR
X=3.315e+03;
Y=3.107e+03(^END

10.8 ERROR MESSAGES

Since the LBA-PC is pretty much of a black box and the GPIB is not much better we have included descriptive error messages and other information to make debugging a little easier.

The LBA-PC maintains two output queues, the response output queue and the error message queue. To enable the error message queue, you must send the ERR command with a parameter specifying verbose error reporting.

The verbose parameter is optional and is a boolean with a value of 0 or 1 (i.e. false or true). The default for the verbose parameter is 1 (true). When verbose error reporting is true then the LBA-PC enables the error message queue.

When the error message queue is enabled and the LBA-PC detects an error then a text string description is placed in the error message queue. The LBA-PC then sets the EMAV bit, bit 3, in the Status Byte to indicate an error message is in the queue.

Perform a serial poll or use the *STB? command to read the status byte. If the EMAV bit is set, use the :ERR? command to read the error message. The EMAV bit will be cleared when the error message queue is empty.

There are three categories of errors, two of which are reported via the error message queue. The first category of errors is remote command errors. These errors include command, execution, and range errors originating directly from commands sent by the host to the LBA-PC.

Example of a category 1 error:

Host sends

:ERR(^END)

Host sends

:APP?(^END)

Host sends

**STB?(^END)*

LBA-PC sends

STB

#H08(^END)

Host sends

:ERR?(^END)

LBA-PC sends

!!! unrecognized command 'APP'(^END)

The second category of errors is LBA-PC execution errors. These error messages are normally displayed in a message box on the screen. The LBA-PC reroutes these error messages to the error message queue when the queue is enabled.

Example of a category 2 error:

Host sends

:PAN

X=0;

Y=0(^END)

Host sends

**STB?(^END)*

LBA-PC sends

STB

#H08(^END)

Host sends

:ERR?(^END)

LBA-PC sends

!!! PAN - 'X=0' out of range (112,744)(^END)

The third category of errors are either fatal or result from some local user action. These errors cannot occur because of remote commands. This third category of errors is always displayed in a message box on the screen and requires user action before continuing. See the ERR specification for the specific errors included in each error category.

Example of a category 3 error:

Operator clicks START!

Host sends

:LDC

Host sends

**STB?(^END)*

LBA-PC sends

STB

#H08(^END)

Host sends

:ERR?(^END)

LBA-PC sends

!!! LDC - cannot load config while running(^END)

10.9 SERVICE REQUEST

10.9.1 Service Request Response

One of the provisions of the GPIB hardware bus is the ability to signal the host controller when an event has occurred. Under the direction of the host controller, the LBA-300PC can assert the SRQ line when new data is available, new results is available, a task has been completed, or an error has occurred. Under the IEEE standard, the controller performs a poll of the devices to determine who requested service and why. A serial poll automatically clears the SRQ.

The LBA-300PC contains six registers that pertain to the SRQ operation. The function of four of these registers is fully explained in the IEEE 488.2 standard. We have modified the definition of some of the bit flags to be more applicable to the operation of the LBA-300PC, and added two registers that are specific to the LBA-300PC. The four IEEE 488.2 registers are accessible through the common command set as follows:

STB - Read the Status Byte. This byte contains the event related flags.

SRE - Write or Read the Service Request Enable byte. These bits determine which of the above Status Byte bits will cause the SRQ to be asserted.

ESR - Read the Event Status Register. This byte contains error bit flags.

ESE - Write or Read the Event Status Enable byte. These bits determine which error condition flags cause the ESB bit to be set and may cause the SRQ to be asserted

The two LBA-300PC specific registers are accessible through commands similar to the common command set as follows:

ELR - Read the LBA-300PC Event Status Register. This byte contains event bit flags.

ELE - Write or Read the LBA-300PC Event Status Enable byte. These bits determine which event flags cause the ELB bit to be set and may cause the SRQ to be asserted.

Appendix A Remote Command/Error Message Operation

The LBA-PC can be controlled as a remote device via GPIB. For the most part, communications between the LBA-PC and the host controller will follow the data format and coding protocols outlined in the IEEE 488.1 and 488.2 standards.

A.1 IEEE 488.1 Command Support

The LBA-PC in combination with an appropriate National Instruments GPIB board conforms to the IEEE 488.1 standard according to the following Subset Codes:

SH1, AH1, T6, L4, SR1, RL2, PP0, DC1, DT0, E2, C0

These Subset Codes are defined in the IEEE 488.1 standard and describe interface capabilities of the LBA-PC.

The following multiple line interface message commands are supported by the LBA-PC:

GTL	Go To Local (0x01). When the LBA-PC detects the GTL message it returns to local command mode.
LLO	Local Lockout (0x11). When the LBA-PC detects the LLO message it enters what is called the lockout state. This is equivalent to entering the operator password in the Options | Password menu item. While in the lockout state access is denied to many of the LBA-PC menu items. When the LBA-PC exits the lockout state access to all menu items is restored.
MLA	My Listen Address (0x20 to 0x3e).
MSA	My Secondary Address (0x60 to 0x7e).
MTA	My Talk Address (0x40 to 0x5e).
PPC	Parallel Poll Configure (0x05). Handled by GPIB board and NI-488.2M.
PPD	Parallel Poll Disable (0x70 to 0x7e). Handled by GPIB board and NI-488.2M.
PPE	Parallel Poll Disable (0x60 to 0x6e). Handled by GPIB board and NI-488.2M.
PPU	Parallel Poll Unconfigure (0x15). Handled by GPIB board and NI-488.2M.
SPD	Serial Poll Disable (0x19).
SPE	Serial Poll Enable (0x18).
UNL	Unlisten (0x3f).
UNT	Untalk (0x5f).

The following IEEE 488.1 commands are <u>not</u> supported:

DCL, GET, SDC, TCT

A.2 IEEE 488.2 Common Commands

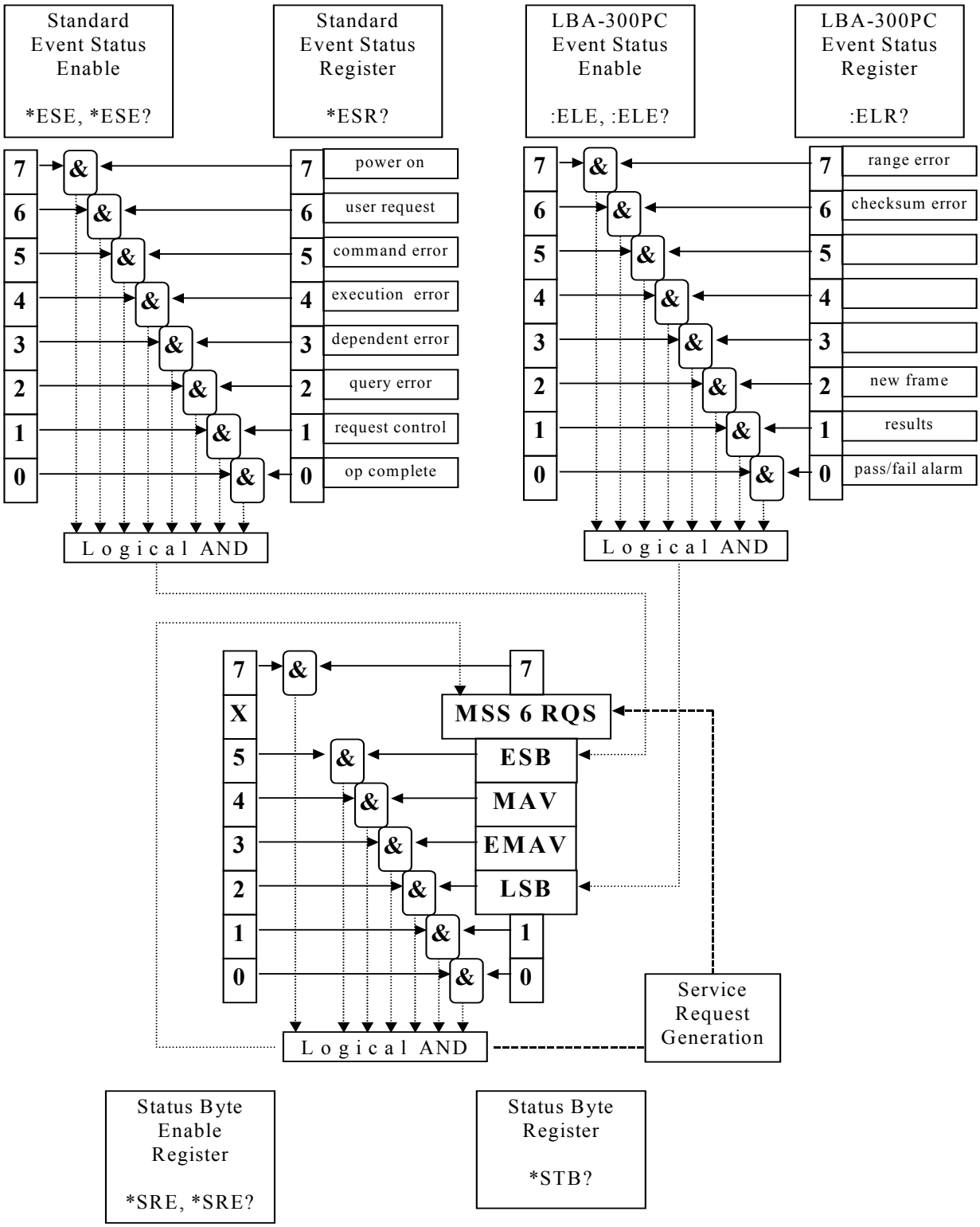
The following IEEE 488.2 common and related commands are supported by the LBA-PC.

Command	Meaning	Usage
*IDN?	Identification	LBA-PC returns the string "Spiricon, LBA-PC, ssss, v.vv" where ssss is the serial number of the board and v.vv is the software version number.
*RST	Reset	Causes the LBA-PC to do the following: Clear ELR, ESR, STB Stop running Restore last configuration saved or restored
:CLR	Clear Queues and Status Registers	Clear output queue (MAV) and error message queue (EMAV). Clear ELR, ESR, STB.
*CLS	Clear Status Registers	Clear ELR, ESR, STB.
:ELE	300PC Event Status Enable	Set mask to enable event status notification of corresponding bits set in ELR.
:ELE?		Return ELE contents.
:ELR?	300PC Event Status Register	Return and clear ELR contents: bit 7 - Range Error flag, set when host attempts to set an input to a value that exceeds permissible range. bit 6 - Checksum Error flag, set when locally computed checksum does not match transmitted value. bit 5 - unused bit 4 - unused bit 3 - unused bit 2 - New Frame Available flag, set each time the LBA-PC has acquired a new frame of data. bit 1 - Results Available flag, set each time the LBA-PC completes a set of computations for a new frame of data. bit 0 - Results Pass/Fail flag, set whenever a pass/fail alarm occurs while running.

Command	Meaning	Usage
*ESE	Event Status Enable	Sets mask to enable event status notification of corresponding bits set in ESR.
*ESE?		Return ESE contents.
*ESR?	Event Status Register	Return and clear ESR contents: bit 7 - Power on. bit 6 - User Request (unused). bit 5 - Command Error flag, set when host sends a command that is not recognized. bit 4 - Execution Error flag, set when the host commands the LBA-PC to perform a task which is preempted by other conditions (e.g. some configurations cannot be set while running, path does not exist, illegal file name, etc.) bit 3 - Device Dependent Error flag (unused). bit 2 - Query Error flag, data in output queue has been lost. bit 1 - Request Control (unused). bit 0 - Operation Complete flag, set when: Ultracal done (only if Ultracal successful) AutoExposure done Generate Gain done Block Capture done Logging done Post Process done (only if stop not caused by error) Statistics done Print done
*SRE	Service Request Enable	Set mask to enable service request notification of corresponding bits in STB.
*SRE?		Return SRE contents.
*STB?	Status Byte	Returns Status Byte contents: bit 7 - unused bit 6 - Master Summary Status, MSS, set whenever an unmasked status condition exists (STB & SRE).

Command	Meaning	Usage
		bit 5 - Event Status bit, ESB, set whenever an unmasked event status condition exists (ESR & ESE). bit 4 - Message Available bit, MAV, set when a response to a query is available in the output queue. bit 3 - Error Message Available bit, EMAV, set when an error message has been posted to the error message queue (see :ERR). bit 2 - LBA-PC Event Status bit, LSB, set whenever an unmasked LBA-PC event status condition exists (ELR & ELE). bit 1 - unused bit 0 - unused

All other IEEE 488.2 common commands are not recognized by the LBA-PC and will return a Command Error.



Service Request Generation

Figure 63

A.3 LBA-PC Command and Data Formats

The LBA-PC does not support the IEEE 488.2 specification of sending multiple commands separated by semicolons. Each command must be sent separately and terminated by asserting the EOI line with the last byte sent.

The following are some typical formats for command and response transmissions:

cmd: *CCC(^END)

cmd: *CCC?(^END)

cmd: *CCC_key=value(^END)

cmd: *CCC_key=value;key=value;…;key=value(^END)

rsp: CCC_key=value;key=value;…;key=value;;(^END)

rsp: CCC_FrameNumber=f;;#dn..n(DAB)(DAB)…(DAB)(DAB)(^END)

Where:

*	=	precedes a 488.2 common command
:	=	precedes a LBA-PC command
CCC	=	three character command code, case is ignored
?	=	query character to illicit a response
_	=	an ASCII SPACE character (0x20)
key	=	command dependent parameter
value	=	value assigned to key
(DAB)	=	8 bit data byte in binary format
(^END)	=	indicates that EOI is asserted with the last byte sent.

A.4 Configuration Command Parameters

Type	**Description**
L	Selection. ASCII numeric value corresponding to the desired selection. All selections start with a base value of zero.
I	Integer. ASCII numeric value in integer format.
B	Boolean. ASCII numeric integer value. 0 = false. 1 = true.

Type	Description
F	Fixed/Floating. ASCII numeric value in fixed or floating point notation.
S	String. Series of ASCII characters. Note that the backslash, "\" has special meaning in strings known as an escape sequence. To specify a single backslash you must send two. For example: "c:\\spiricon\\lba300pc\\lbapc.cfg" is interpreted as "c:\spiricon\lba300pc\lbapc.cfg". Although other escape sequences are recognized, there is no reason to use them with the LBA-PC.
T	Time. ASCII numeric integer values in the form [[HHH:]MM:]SS.
D	Date. ASCII numeric integer values in the form MM/DD/YY.

A.5 LBA-PC Configuration Commands

A.5.1 File Menu

If a key is not specified with the command then the default is the last value set via restore config, or a previous command (unless otherwise specified in the description).

Many commands can generate error messages. See the :ERR? query command for a list of error messages

Range checking is performed on all values in key=value for each transmitted command. If any value is invalid or out of range then the entire command is ignored and the Range Error flag is set in ELR.

All footnote references can be found on the last page of this Appendix.

A.5.1.1 LDC - restore configuration

NOTE: There is no default path for this command. If you want the configuration to be restored from a particular path then send the path with the file name.

:LDC <configuration>[1,3]

:LDC?

Key	Type	Value Description
ConfigFileName[6]	S	Name of configuration file to load. If no extension (i.e. no period) then .CFG is

Key	Type	Value Description
		appended. Maximum 256 characters. default = drive, path, and filename from last load or save config

A.5.1.2 SDC - save configuration

NOTE: There is no default path for this command. If you want the configuration to be saved in a particular path then send the path with the file name.

:SDC <configuration>[1,3]

:SDC

Key	Type	Value Description
ConfigFileName[6]	S	Name of configuration file to load. If no extension (i.e. no period) then .CFG is appended. Maximum 256 characters. default = drive, path, and filename from last load or save config

A.5.1.3 LDD - load data from file

NOTE: There is no default path for this command. If you want the data file to be loaded from a particular path then send the path with the file name.

:LDD <configuration>[1,3]

:LDD?

Key	Type	Value Description
FileName[6]	S	Name of file to load. If no extension (i.e. no period) then .LB3/4/5/7 is appended to data and reference frames. .GAI is appended to gain frame files. Maximum 256 characters. default = filename from last load or save data command.
StartRecord	I	Number of frames to write.

Key	Type	Value Description
		1 to n. 'n' is the number of records in the file.
NumberRecords	I	0 = all records (up to frame buffer size) 1 to n. 'n' is the size of the frame buffer. forced to 1 when StartFrame < 1
StartFrame	I	First frame saved. -1 = gain frame 0 = reference frame 1 to n. 'n' is the size of the frame buffer default = current frame
Replace	B	true = replace If the camera or the camera resolution stored in the file do not match the current configuration then the LBA-PC must replace the current camera or change the resolution before the frame can be loaded. Either of these changes results in clearing the frame buffer (i.e., all current frames are discarded). If the pixel scale stored in the file does not match the current pixel scale then the pixel scale will be set to the value in the file. false = do not replace If the camera or camera resolution stored in the file do not match then an error is generated. forced to false when StartFrame < 1 default = false

A.5.1.4 SDD - save data to file

NOTE: There is no default path for this command. If you want the to be saved in a particular path then send the path with the file name.

:SDD <configuration>[1,3]

:SDD?

Key	Type	Value Description
FileName[6]	S	Name of file to load. If no extension (i.e., no period) then .LB3/4/5/7 is appended to data, reference, and ultracal frames. .GAI is appended to gain frame files.

Key	Type	Value Description
		Maximum 256 characters. default = filename from last load or save data command
NumberRecords	I	0 = all records (up to frame buffer size) 1 to n. 'n' is the size of the frame buffer. forced to 1 when StartFrame < 1
StartFrame	I	First frame saved. -1 = gain frame 0 = reference frame 1 to n. 'n' is the size of the frame buffer. default = current frame
Append	B	Append existing file false = do not append The file will be created if it does not exist. An error occurs if Replace is also false and the file exists. true = append to existing file The file will be created if it does not exist. Frames will be appended to the file if it exists. An error occurs if the file exists and the file's version, camera, or resolution do not match the current configuration. forced to false when StartFrame < 1 default = true
Replace	B	Overwrite existing file. If this key is true then the Append key is ignored. false = do not overwrite The file will be created if it does not exist. An error occurs if Append is also false and the file exists. true = overwrite existing file The file will be created if it does not exist. The file will be replaced if it exists. forced to true if StartFrame < 1 default = false

A.5.1.5 EXP - set export configuration & export image(s)

:EXP <configuration>[1]

:EXP?

Key	Type	Value Description
Export[3]	B	false = set configuration only. true = set configuration then export images. Images cannot be exported while running. default = true
Replace	B	Overwrite if file exists. default = false
ExportFileName[6]	S	Base name of export file. Extension automatically created by LBA-PC based on export file type. Maximum 256 characters.
StartFrame	I	First frame to export. 1 to n. 'n' is the size of the frame buffer.
NumberFrames	I	Number of frames to export. 0 = all frames 1 to n. 'n' is the size of the frame buffer.
BMP	B	.BMP export enable.
AsciiComma	B	.CMA export enable.
AsciiSpace	B	.SPC export enable.
CursorData	B	.CUR export enable.
ColumnRowSum	B	.SUM export enable.

A.5.1.6 LOG - set logging configuration

NOTE: There is no default path for this command. If you want the data log file, results log file, or export log file(s) to be saved in a particular path then send the path with the file name.

Data & Results logging will append to an existing file once opened. It will overwrite an existing file if newly opened. Export logging will always overwrite an existing file. No warning or error message is given in either instance.

:LOG <configuration>[1,3]

:LOG?

Key	Type	Value Description
DataLogging	B	Data logging enable.
DataFileName	S	Name of data log file. If no extension (i.e., no period) then .LB3/4/5/7 is appended. Maximum 256 characters. If this key is set to "FRM" or "RDD" (case ignored) (or was previously set to FRM or RDD in the dialog) then data frames will be logged to the GPIB bus. Each time a new frame is captured the LBA-PC will automatically send a response as if you had sent ":FRM?" or "RDD?" respectively. You must address the LBA-PC to talk and be prepared to accept the transmitted data. The LBA-PC will wait until you have read the data before capturing another frame. *Note: FRM and RDD are ignored if the LBA-PC is not in remote.*
ResultsLogging	B	Results logging enable.
ResultsFileName	S	Name of results log file. If no extension (i.e., no period) then .RLG is appended. Maximum 256 characters. If this key is set to "RDR" (case ignored) (or was previously set to RDR in the dialog) the results will be logged to the GPIB bus. Each time results are computed for a new frame the LBA-PC will automatically send a response as if you had sent ":RDR? Values=1". The LBA-PC will wait until you have read the data before capturing another frame. *Note, in this case the results format is ignored. Note: RDR is ignored if the LBA-PC is not in remote.*
ResultsFormat	L	Results log format. 0 = math 1 = spreadsheet
ExportLogging	B	Export logging enable.
ExportFileName	S	Name of export log file. Any file extension is ignored and an appropriate extension is used depending on the type of export file that is being logged.
BMP	B	.BMP logging enable.

Key	Type	Value Description
AsciiComma	B	.ASC logging enable.
AsciiSpace	B	.ASP logging enable.
CursorData	B	.CUR logging enable.
ColumnSumRow	B	.SUM logging enable.
LoggingMethod	L	Logging duration. 0 = continuous 1 = frames 2 = time
NumberFrames	I	Number of frames to log, if LoggingMethod is frames. 1 to 100000.
Time	T	Amount of time to log, if LoggingMethod is time. 0:0:1 to 999:59:59
PassFailFilter	L	Which frames to log. 0 = all 1 = passed 2 = failed

A.5.1.7 GAI - generate gain frame

This command is equivalent to selecting File | Generate Gain. To read or write the gain frame data use the RDD or FRM command with the StartFrame parameter set to -1.

:GAI[3]

A.5.1.8 REF - set reference

This command is equivalent to File | Set Reference. To read or write the reference frame data use the RDD or FRM command with the StartFrame parameter set to 0.

:REF[3]

A.5.1.9 PRN - set print configuration and print

:PRN <configuration>[1]

:PRN?[2]

Key	Type	Value Description

Key	Type	Value Description
Print[3]	B	start printing now default = true
BeamImage	B	Print beam enable.
Results	B	Print results enable.
SeparatePages	B	Print beam and results on separate pages.
CurrentOnly	B	Print current frame only.
StartFrame	I	First frame to print. 1 to n. 'n' is the frame buffer size. default = current frame.
NumberFrames	I	Number of frames to print. 0 = all frames 1 to n. 'n' is the frame buffer size.
2DdarkBackground	B	2D beam print dark background.

A.5.2 Options Menu

A.5.2.1 APT - set aperture configuration

:APT <configuration>[1]
:APT?[2]

Key	Type	Value Description
DrawShape	L	Shape of user drawn aperture. 0 = none 1 = circle 2 = square 3 = ellipse 4 = rectangle
CenterXLoc	F	x location in world coordinates[5]
CenterYLoc	F	Y location in world coordinates[5]
Major	F	major axis length in world coordinates[5]
Minor	F	minor axis width in world coordinates[5]
Rotation	I	-90 to 90
DisplayShape	L	Shape of computed display aperture. 0 = none 1 = circle

Key	Type	Value Description
		2 = square 3 = ellipse 4 = rectangle
AutoAperture	B	Auto aperture enable.

A.5.2.2 CAM - set camera configuration

A path may be included in the 'File' parameter. If a path is included in the 'File' parameter then the path where the LBA-PC looks for CAM files will also be changed.

If a 'File' is specified the current settings for Resolution, FrameBufferSize, NumberFrames, and Lens are not changed.

If a 'File' is specified then this file is read first. Parameters such as Pixel Scale, Pixel Units, Gamma & Lens can be specified to override the default CAM file parameters.

If 'File' or 'Resolution' is specified that is different from the current configuration then the frame buffer will be flushed and all current frame data will be lost.

If 'FrameBufferSize' or 'NumberFrames' specified is less than the current configuration then frames at the end of the frame buffer will be discarded.

:CAM <configuration>[1]

:CAM?[2]

Key	Type	Value Description
File3	S	CAM file name. Maximum 256 characters.
Resolution3	L	Full frame video sample rate. Maximum value depends on camera. -1 = Full 1x 0 = 1x 1 = 2x 2 = 4x 3 = 8x 4 = 16x
NumberFrames3	I	Number of frames in frame buffer
Sync Source	L	Camera sync source. 0 = Genlock 1 = Digital
PixelBits	I	Number of digitized bits/pixel. Available only when Sync Source is set to Digital.

Key	Type	Value Description
		8 to 15, -8 to -15
PixelHScale	F	Horizontal pixel scale. Forced equal to vertical pixel scale if SyncSource is genlock
PixelVScale4	F	Vertical pixel scale.
PixelUnits	L	Pixel scale units display. 0 = none 1 = μm 2 = mm 3 = cm 4 = m 5 = in 6 = mils 7 = mrad
Gamma	F	Camera gamma value. 0.1 to 10.0
Lens	B	Invert image enable (if camera is fitted with a lens)

A.5.2.3 CAP - set capture configuration

:CAP <configuration>[1]

:CAP?[2]

Key	Type	Value Description
CaptureMethod	L	Capture Method. 0 = continuous 1 = single 2 = block 3 = live
CaptureInterval	I	Frames between captures. 1 to 100000.
BlockLength	I	Number of frames to capture in block mode. 1 to 100000.

Key	Type	Value Description
CameraInput	B	Which camera input is in use. Cannot be set. To select which camera is in use, set only one of the CameraInput# below. 0, or 1 to 3 if you purchased the four-camera option.
CameraInput2 CameraInput3 CameraInput4	B	Which camera input(s) to use. Valid only if you purchased the four-camera option.
CameraShutter	L	Camera shutter setting for camera 1. 0 to 7. Effect depends on camera.
CameraShutter2 CameraShutter3 CameraShutter4	B	Camera shutter setting for cameras 2 to 4. Valid only if you purchased the four-camera option. 0 to 7. Effect depends on camera.
CameraGainEffect	F	Camera input gain for camera 1. 1.0 to 5.0, equivalent gain multiplier effect
CameraGainEffect2 CameraGainEffect3 CameraGainEffect4	F	Camera input gain for cameras 2 to 4. Valid only if you purchased the four-camera option. 1.0 to 5.0, equivalent gain multiplier effect
CameraBlack	I	Camera input black level for camera 1. 0 to 511.
CameraBlack2 CameraBlack3 CameraBlack4	I	Camera input black level for cameras 2 to 4. Valid only if you purchased the four-camera option. 0 to 511.
TriggerType	L	Trigger type. 0 = cw 1 = out 2 = video 3 = in
TriggerOutAlways	B	Trigger out always enable.
TriggerOutDelay	B	Trigger out delay enable.
TriggerPolarity	L	Trigger out polarity. 0 = negative 1 = positive
TriggerInterval	I	Frames between triggers. 1 to 100000.

Key	Type	Value Description
VideoTriggerLevel	L	Video trigger level for camera 1. 0 = 1/16 maximum pixel value 1 = 1/8 maximum pixel value 2 = 1/4 maximum pixel value 3 = 1/2 maximum pixel value
VideoTriggerLevel2 VideoTriggerLevel3 VideoTriggerLevel4		Video trigger level for cameras 2 to 4. Valid only if you purchased the four-camera option. 0 = 1/16 maximum pixel value 1 = 1/8 maximum pixel value 2 = 1/4 maximum pixel value 3 = 1/2 maximum pixel value
Summing	B	Sum frames enable.
SummingFrames	I	Number of frames to sum. 2 to 256
Average	B	Average frames enable.
AverageFrames	I	Number of frames to average. 2 to 256
GainCorrect	B	Gain correct enable.
ReferenceSubtract	B	Reference subtract enable.
ReferenceSource	L	Reference source. 0 = frame 1 = gauss 2 = auto gauss
Convolution	L	Convolution enable. 0 = none 1 = LPF1 3x3 2 = LPF1 5x5 3 = LPF1 7x7 4 = LPF2 3x3 5 = LPF3 3x3
MaxFrameSize[4]	I,I	X,Y maximum frame size based on camera and selected camera resolution
ZoomIndex[4]	L	Zoom level. Depends on camera and camera resolution (see ZOM? and ZMM?).

Key	Type	Value Description
		0 to NumZooms-1.
NumZooms[4]	I	Maximum zoom index value
CaptureLocation[4]	I,I	X,Y upper left corner of capture area (see PAN)
CaptureSize[4]	I,I	Width and height of frame These values are set via ZoomIndex
CaptureResolution[4]	L	Capture sample resolution. -1 = Full 1x 0 = 1x 1 = 2x 2 = 4x 3 = 8x 4 = 16x 5 = 32x This value is set via ZoomIndex.

A.5.2.4 COM - set computations configuration

:COM <configuration>[1]

:COM?[2]

Key	Type	Value Description
EnergyOfBeam	F	Beam energy. Will calibrate the currently displayed frame to this value.
EnergyOfFrame4	F	Raw frame total at time EnergyOfBeam is entered.
EnergyUnits	L	Calibrated energy units. 0 = j 1 = mj 2 = uj 3 = nj u = pj 5 = w 6 = mw 7 = uw 8 = nw

Key	Type	Value Description
		9 = pw 10 = fl
Quant	B	Quantitative results enable.
BeamWidthMethod	L	Beam width method. 0 = 4 sigma 1 = knife edge 90/10 2 = knife edge 3 = energy (uses ClipHigh) 4 = peak
ClipLow	F	1 to 99, < ClipHigh
ClipHigh	F	1 to 99, > ClipLow
Multiplier	F	Knife edge multiplier 1 to 10
Ellip	B	Elliptical results enable.
Gauss	B	Gauss fit enable.
GaussMethod	L	Gauss fit method. 0 = whole 1 = x/y or major/minor
Tophat	B	Tophat enable.
TophatMethod	L	Tophat method. 0 = data 1 = area 2 = line
Divergence	B	Divergence enable.
Divergence Method	L	Divergence method. 0 = focal length 1 = far field
FocalLength	F	Lens focal length 0 to 10000
Separation	F	Far field separation 0 to 10000
XreferenceDiameter	F	X reference diameter 0 to 1.0e12
YreferenceDiameter	F	Y reference diameter

Key	Type	Value Description
		0 to 1.0e12
Histogram	B	Histogram enable.
Buckets	I	Histogram bucket width, 1 to 256
Statistics	B	Statistics enable.
StatisticsMethod	L	Statistics method. 0 = continuous 1 = frames 2 = time
Frames	I	Number of frames to collect, if statistics method is frames. 1 to 100,000
Time	T	Amount of time to collect statistics, if statistics method is time. 0:0:1 to 999:59:59

A.5.2.5 DIS - set display configuration

:DIS <configuration>[1]

:DIS? [2]

Key	Type	Value Description
BeamView2D	B	Beam display type. false = 3D true = 2D
Cursors	L	Cursor display enable. 0 = off 1 = manual 2 = centroid 3 = peak
CursorProfiles	B	Cursor profile display enable.
Origin	L	Spatial coordinate origin. 0 = manual 1 = detector upper left 2 = detector lower left 3 = window upper left

Key	Type	Value Description
		4 = window lower left
ManualOrigin	I	X,Y detector location of manual origin. Range depends on camera.
BeamColors	L	Beam display color. 0 = bands 1 = continuous 2 = gray scale 3 = user specified palette 4 = green 5 = yellow
PaletteFileName		Name of the color palette file. Maximum 256 characters. default = drive, path, name of lat palette file loaded.
ScaleType	L	Beam display scale. 0 = x1 1 = x2 2 = x4 3 = x8 4 = x16 5 = auto
BeamDisplay	L	What beams to display. 0 = current 1 = current & reference 2 = current & current - reference 3 = current & current + reference 4 = reference 5 = current - reference 6 = current + reference
ReferenceSource	L	Reference source. 0 = frame 1 = gauss 2 = auto gauss
LowerThreshold	F	Lower color *energy* display threshold. If *energy* is uncalibrated (COM,

Key	Type	Value Description
		EnergyOfBeam=0) then the range is 0 to 255. If *energy* is calibrated then the range depends on the *energy* calibration.
UpperThreshold	F	Upper color *energy* display threshold. If *energy* is uncalibrated (COM, EnergyOfBeam=0) then the range is 0 to 255. If *energy* is calibrated then the range depends on the *energy* calibration.
ColorBar	B	Color bar display enable.
CursorAxis	L	Cursor axis orientation. 0 = x/y 1 = major/minor
Crosshair	L	Crosshair display enable. 0 = off 1 = manual 2 = centroid 3 = peak 4 = origin
Grid	B	2D grid enable.
CrossHatch	B	3D crosshatch enable.
Contour	B	3D contour enable.
WireFrame	B	3D wire frame enable.
Rotate	I	3D display rotation. 0 to 359.
Tilt	I	3D display tilt. 0 to 90
Slice	L	3D wire density display. 0 = frame size 1 = ½ frame size 2 = ¼ frame size 3 = etc. Minimum display is 16 X 15.

A.5.2.6 PSW - enter password

:PSW <configuration>

Key	Type	Value Description
Password	S	See online help under Password Lockout for information about passwords.

:PSW?

Returns:

PSW < configuration >

Key	Type	Value Description
Lockout	B	true = local lockout active

A.5.3 Pass/Fail Menu

A.5.3.1 PFF - set pass/fail master configuration

:PFF <configuration>[1]

:PFF? [2]

Key	Type	Value Description
PassFail	B	Master Pass/Fail enable.
TTL	B	TTL output on 'When' condition enable.
Beep	B	Beep on 'When' condition enable.
Stop	B	Stop on 'When' condition enable.
When	L	Pass/Fail condition that invokes TTL, Beep, Stop. 0 = fail 1 = pass

A.5.3.2 pass/fail quant configuration

Key	Type	Value Description
Total	B,B	Min,Max test enable.

Key	Type	Value Description
TotalMin	F	Total *energy* minimum. -1e12 to 1e12
TotalMax	F	Total *energy* maximum. -1e12 to 1e12
Percent	B,B	Min,Max test enable.
PercentMin	F	Percent of *energy* minimum. 0 to 100
PercentMax	F	Percent of *energy* maximum. 0 to 100
PeakFluence	B,B	Min,Max test enable.
PeakFluenceMin	F	Peak fluence minimum. -1e12 to 1e12
PeakFluenceMax	F	Peak fluence maximum. -1e12 to 1e12.
ValleyFluence	B,B	Min,Max test enable.
ValleyFluenceMin	F	Min fluence minimum. -1e12 to 1e12.
ValleyFluenceMax	F	Min fluence maximum. -1e12 to 1e12.
Centroid	B	Centroid test enable.
CentroidXLoc	F	X location in world coordinates[5]. -1e12 to 1e12.
CentroidYLoc	F	Y location in world coordinates[5]. -1e12 to 1e12.
CentroidRadius	F	Maximum distance from (CentroidXLoc,CentroidYLoc) in world coordinates[5] 0 to 1e12.
Major	B,B	Min,Max test enable.
MajorMin	F	Major axis minimum in world coordinates[5]. 0 to 1e12.
MajorMax	F	Major axis maximum in world coordinates[5]. 0 to 1e12.

Key	Type	Value Description
Minor	B,B	Min,Max test enable.
MinorMin	F	Minor axis minimum in world coordinates[5]. 0 to 1e12.
MinorMax	F	Minor axis maximum in world coordinates[5]. 0 to 1e12.
Diameter	B,B	Min,Max test enable.
DiameterMin	F	Diameter minimum in world coordinates[5]. 0 to 1e12.
DiameterMax	F	Diameter maximum in world coordinates[5]. 0 to 1e12.

A.5.3.3 pass/fail elliptical configuration

Key	Type	Value Description
Roundness	B,B	Min,Max test enable.
RoundnessMin	F	Roundness minimum. 0 to 1
RoundnessMax	F	Roundness maximum. 0 to 1
Orientation	B	Orientation test enable.
RotateOrientation	I	Rotation base. -90 to 90
RotateRange	I	Rotation maximum. 0 to 90

A.5.3.4 pass/fail gauss configuration

Key	Type	Value Description
GaussCentroid	B	Gauss centroid test enable.
GaussCentroidXLoc	F	X location in world coordinates[5].

Key	Type	Value Description
		-1e12 to 1e12.
GaussCentroidYLoc	F	Y location in world coordinates[5]. -1e12 to 1e12.
GaussCentroidRadius	F	Maximum distance from (CentroidXLoc, CentroidYLoc) in world coordinates[5] 0 to 1e12.
GaussCentroidMinor	B	Minor or Y axis centroid test enable.
GaussCentroidRadiusMinor	F	Maximum distance from GaussCentroidMinor in world coordinates[5] 0 to 1e12.
GaussMajor	B,B	Min,Max test enable.
GaussMajorMin	F	Major axis or Width X minimum in world coordinates[5]. 0 to 1e12.
GaussMajorMax	F	Major axis or Width X maximum in world coordinates[5]. 0 to1e12.
GaussMinor	B,B	Min,Max test enable.
GaussMinorMin	F	Minor axis or Width Y minimum in world coordinates[5]. 0 to 1e12.
GaussMinorMax	F	Minor axis or Width Y maximum in world coordinates[5]. 0 to 1e12.
GaussHeight	B,B	Min,Max test enable.
GaussHeightMin	F	Gauss Height, Gauss Height Major, or Gauss Height X; minimum. -1e12 to 1e12.
GaussHeightMax	F	Gauss Height, Gauss Height Major, or Gauss Height X; maximum. -1e12 to 1e12.
GaussCorrelation	B,B	Min,Max test enable.

Key	Type	Value Description
GaussCorrelationMin	F	Gauss Correlation, Gauss Correlation Major, or Gauss Correlation X; minimum. 0 to 1.
GaussCorrelationMax	F	Gauss Correlation, Gauss Correlation Major, or Gauss Correlation X; maximum. 0 to 1.
GaussDeviation	B,B	Min,Max test enable.
GaussDeviationMin	F	Gauss Deviation, Gauss Deviation. Major, or Gauss Deviation. X; minimum. 0 to 1e12.
GaussDeviationMax	F	Gauss Deviation, Gauss Deviation Major, or Gauss Deviation X; maximum. 0 to 1e12.
GaussHeightMinor	B,B	Min,Max test enable.
GaussHeightMinorMin	F	Gauss Height Minor, or Gauss Height Y; minimum. -1e12 to 1e12
GaussHeightMinorMax	F	Gauss Height Minor, or Gauss Height Y; maximum. -1e12 to 1e12
GaussCorrelationMinor	B,B	Min,Max test enable.
GaussCorrelationMinorMin	F	Gauss Correlation. Minor, or Gauss Correlation X; minimum. 0 to 1.
GaussCorrelationMinorMax	F	Gauss Correlation. Minor, or Gauss Correlation X; maximum. 0 to 1.
GaussDeviationMinor	B,B	Min,Max test enable.
GaussDeviationMinorMin	F	Gauss Deviation Minor, or Gauss Deviation Y; minimum.

Key	Type	Value Description
		0 to 1e12.
GaussDeviationMinorMax	F	Gauss Deviation Minor, or Gauss Deviation Y; maximum. 0 to 1e12.

A.5.3.5 pass/fail top hat configuration

Key	Type	Value Description
TophatFluence	B,B	Min,Max test enable.
TophatFluenceMin	F	Tophat Fluence, or Tophat Fluence X; minimum. -1e12 to 1e12.
TophatFluenceMax	F	Tophat Fluence, or Tophat Fluence X; maximum. -1e12 to 1e12.
TophatMean	B,B	Min,Max test enable.
TophatMeanMin	F	Tophat Mean, or Tophat Mean X; minimum. -1e12 to 1e12.
TophatMeanMax	F	Tophat Mean, or Tophat Mean X; maximum. -1e12 to 1e12.
TophatDeviation	B,B	Min,Max test enable.
TophatDeviationMin	F	Tophat Deviation, or Tophat Deviation X; minimum. -1e12 to 1e12.
TophatDeviationMax	F	Tophat Deviation, or Tophat Deviation X; maximum. -1e12 to 1e12.
TophatSDM	B,B	Min,Max test enable.
TophatSDMMin	F	Tophat SD/M, or Tophat SD/M X; minimum. 0 to 1e3.

Key	Type	Value Description
TophatSDMMax	F	Tophat SD/M, or Tophat SD/M X; maximum. 0 to 1e3.
EffectiveArea	B,B	Min,Max test enable.
EffectiveAreaMin	F	Effective area minimum. 0 to 1e12.
EffectiveAreaMax	F	Effective area maximum. 0 to 1e12.
EffectiveDiameter	B,B	Min,Max test enable.
EffectiveDiameterMin	F	Effective diameter minimum. 0 to 1e12.
EffectiveDiameterMax	F	Effective diameter maximum. 0 to 1e12.
TophatFactor	B,B	Min,Max test enable.
TophatFactorMin	F	Tophat factor minimum. 0.0 to 1.0
TophatFactorMax	F	Tophat factor maximum. 0.0 to 1.0
TophatMeanMinor	B,B	Min,Max test enable.
TophatMeanMinorMin	F	Tophat Mean Y minimum. -1e12 to 1e12.
TophatMeanMinorMax	F	Tophat Mean Y maximum. -1e12 to 1e12.
TophatFluenceMinor	B,B	Min,Max test enable.
TophatFluenceMinorMin	F	Tophat Fluence Y minimum. -1e12 to 1e12.
TophatFluenceMinorMax	F	Tophat Fluence Y maximum. -1e12 to 1e12.
TophatDeviationMinor	B,B	Min,Max test enable.
TophatDeviationMinorMin	F	Tophat deviation Y minimum. -1e12 to 1e12.
TophatDeviationMinorMax	F	Tophat deviation Y maximum. -1e12 to 1e12.

Key	Type	Value Description
TophatSDMMinor	B,B	Min,Max test enable.
TophatSDMMinorMin	F	Tophat SD/M Y minimum. 0 to 1e3.
TophatSDMMinorMax	F	Tophat SD/M Y maximum. 0 to 1e3.

A.5.3.6 pass/fail divergence configuration

Key	Type	Value Description
DivergenceMajor	B,B	Min,Max test enable.
DivergenceMajorMin	F	Divergence X or Major min., in milli-radians. 0.0 to 3142.0.
DivergenceMajorMax	F	Divergence X or Major max., in milli-radians. 0.0 to 3142.0.
DivergenceMinor	B,B	Min,Max test enable.
DivergenceMinorMin	F	Divergence Y or Minor min., in milli-radians. 0.0 to 3142.0.
DivergenceMinorMax	F	Divergence Y or Minor max., in milli-radians. 0.0 to 3142.0.

A.5.4 Remote Specific Commands

If a key is not specified with the command then the default value is the last value set (restore config, previous command) unless otherwise specified in the description.

Range checking is performed on all values in key=value for each transmitted command. If any value is invalid or out of range then the entire command is ignored and the range error bit is set (see :ELR?).

A.5.4.1 CAL - ultra cal

:CAL <configuration>[3]

If you do not send a parameter then the LBA-PC begins an automatic camera calibration process. When the process is completed the LBA-PC sets the Operation Complete bit (bit 0) in the Event Status Register (see *ESR).

Key	Type	Value Description
UltracalOff	B	true = disable frame calibration default = false

A.5.4.2 CHR - read/write cross hair location

This command is valid only when cross hair is set to manual (see :DIS). The range of allowable values is returned by the WLD? command.

:CHR <configuration>

Key	Type	Value Description
X	F	x location in world coordinates[5]
Y	F	y location in world coordinates[5]
Cursor	B	true = snap the cross hair to the location of the cursor. Any X or Y values in the same command are ignored. default = false

:CHR?

Returns:

CHR <configuration>[2]

If cross hair is set to centroid, peak, or origin then returns centroid, peak, or origin location respectively. Otherwise returns manual cross hair location.

A.5.4.3 CUR - read/write cursor location

This command is valid only when cursor is set to manual (see :DIS). The range of allowable values is returned by the WLD? command.

:CUR <configuration>

Key	Type	Value Description
X	F	x location in world coordinates[5]
Y	F	y location in world coordinates[5]

:CUR?

Returns:

CUR <configuration>[2]

Key	Type	Value Description
X	F	x location in world coordinates5
Y	F	y location in world coordinates5
Z	F	Value of pixel at cursor
Delta	F	distance from cross hair to cursor

A.5.4.4 DSF - display frame

:DSF <configuration>[3]

:DSF?

Key	Type	Value Description
FrameNumber	I	frame number -1 = gain frame 0 = reference frame 1 to n. 'n' is the size of the frame buffer default = current frame

A.5.4.5 ERR - error reporting

:ERR <configuration>

Key	Type	Value Description
Verbose	B	true = remote error messages if a communications error occurs then the EMAV bit is set in the status byte (STB) and a text message containing a brief explanation of the error is placed in the error message queue. To retrieve error messages use ":ERR?". All error messages begin with the characters "!!!". default = true

:ERR?

A separate output queue is maintained for error messages. Each time :ERR? is received the LBA-PC returns the next message in the error message queue. If the queue is empty the LBA-PC returns the current verbose setting, i.e. "ERR Verbose=b". The status of the error message

queue can be monitored with the EMAV bit in the status byte register (STB). This bit is set when one or more messages is in the error message queue. This bit is cleared when the queue is empty.

Note that you must set ":ERR Verbose=1" to receive error messages. If Verbose=0 then no messages will be put into the error message queue and EMAV will remain clear.

Following is a list of possible remote error messages:

Message	**Error Type**	**Description**
Ibrd() time-out	EXECUTION_ERROR	LBA-PC was addressed to listen. A time-out occurred when the LBA-PC tried to read from the bus. Any data received will be discarded.
ibwrt() time-out	EXECUTION_ERROR	LBA-PC was addressed to talk. A time-out occurred when the LBA-PC tried to write to the bus. The LBA-PC will attempt to resend the entire response.
unrecognized command	COMMAND_ERROR	Command is unknown or not supported, or attempt to set a register that is read-only (ELR, ESR, STB, etc.)
Bad int parameter	COMMAND_ERROR	Integer parameter missing or unsupported format (binary is not supported)
query not allowed	COMMAND_ERROR	A command was sent with a question mark at the end, but a query is not allowed
unrecognized key	COMMAND_ERROR	LBA-PC detected a key it does not recognize. The LBA-PC does not always detect such keys.
cannot be set	COMMAND_ERROR	A key was specified whose value cannot be set
Bad file name	EXECUTION_ERROR	The specified file or path does not exist
Out of range	RANGE_ERROR	The indicated key=value is out of range
contains no data	EXECUTION_ERROR	FRM,RDD - The requested frame contains no data
different camera	EXECUTION_ERROR	FRM,LDD,SDD - The specified frame was captured using a different camera than the

Message	Error Type	Description
		current configuration and Replace=false
different camera resolution	EXECUTION_ERROR	FRM,LDD,SDD - The specified frame was captured at a different camera resolution than the current configuration and Replace=false
cannot set while running	EXECUTION_ERROR	The specified value(s) cannot be set while the LBA-PC is running
CAM file error	EXECUTION_ERROR	CAM - There was an error reading a specified CAM file (check path, filename, contents)
file name contains illegal characters	EXECUTION_ERROR	LDD, SDD, DIS
directory path does not exist	EXECUTION_ERROR	LDD, SDD, DIS
error in directory path or file name	EXECUTION_ERROR	LDD, SDD, DIS
file error	EXECUTION_ERROR	LDD,SDD - An unknown error occurred while reading or writing respectively the file.
file does not exist	EXECUTION_ERROR	LDD, DIS
Not a valid LBA-PC data file	EXECUTION_ERROR	LDD, SDD
cannot write to file created by previous version of LBA-PC	EXECUTION_ERROR	SDD
This is not a Demo frame	EXECUTION_ERROR	LDD, SDD - The demonstration version of the LBA-PC cannot read or write files created by the commercial version.
Invalid frame size	EXECUTION_ERROR	REF - The frame is not a normal LBA-PC frame size (i.e. 120x120 .LBA) and cannot be used as the reference frame.

Message	Error Type	Description
crosshair mode not set to manual	EXECUTION_ERROR	CHR
not in remote	EXECUTION_ERROR	SYC - Cannot synchronize with remote if GPIB interface is in local mode. (see SYC, LOC, REM)

Following is a list of error messages that normally appear on the display. These messages are automatically rerouted to the error message queue when LBA-PC is in remote control mode.

Message	Generated By
Cannot run Ultracal because all frames are write protected.	Ultracal!
The Camera Gain is set too high.	Ultracal!
Camera Black Level range exceeded.	Ultracal!
Please block the beam.	Ultracal!
No Camera Video Input.	capture
Cannot start running because all frames are write protected.	capture post process
Post Process file does not exist. Processing Aborted.	post process
File record header does not match current configuration. Processing Aborted.	post process
This is not a valid LBA-PC data file. Processing Aborted.	post process
End of Post Process file. Processing Stopped.	post process
Attempt to read beyond end of file. Processing Aborted.	post process
This is not a Demo frame. Processing Aborted.	post process
Frame %d contains no data. Processing Aborted.	post process
Frame size of this record %ld is %d X %d. Frame size of first record is %d X %d. Processing Aborted.	post process
Data logging file and Post Process file are the same.	post process

Message	Generated By
File name contains illegal characters	File | Export
Directory path does not exist	File | Export
Error in directory path or file name	File | Export
File error	File | Export
Error reading Gain file.	File | Load Gain
some value in the Gain file is greater than maximum allowed value of 2. Load Gain Aborted.	File | Load Gain
Some value in the Gain file is less than 0. Load Gain Aborted.	File | Load Gain
Error writing Gain file.	File | Save Gain As
Some value in the Gain frame is 0. Generate Gain Aborted.	File | Generate Gain
Some value in the Gain frame is greater than maximum allowed value of 2. Generate Gain Aborted.	File | Generate Gain
Check Data Logging Path.	logging
Check Results Logging Path.	logging
Check Export Logging Path.	logging
Resetting Statistics to zero.	statistics
Insufficient memory to compute aperture.	results
Error Writing Configuration.	File | Save Config
Error in configuration path or file name.	File | Save Config File | Restore Config
Frame %d contains no data. Save aborted	File | Save As

The following error messages will always appear on the display and may disrupt GPIB communications.

Message	Generated By
Cannot Load file because all frames are write protected.	File | Load
File camera does not match current camera.	File | Load
File record header does not match current configuration.	File | Load
This is not a valid LBA-PC data file.	File | Load
This is not a Demo file.	File | Load
Insufficient memory for dialog box.	dialog
Out of memory	dialog
TFileSaveDialog returned Error #%lx	dialog
TFileOpenDialog returned Error #%lx	dialog
You have changed the Camera. All frame data will be lost. Press OK to continue.	camera dialog
You have changed the Resolution. All frame data will be lost. Press OK to continue.	camera dialog
You have reduced the number of Frames. Frames at the end of the buffer will be lost. Press OK to continue.	camera dialog
X1 Camera Buffer Resolution is not allowed with this style camera and Trigger In/Out or Video Trigger.	camera dialog
Trigger In/Out and Video Trigger are not allowed with this style camera in X1 Camera Buffer Resolution.	capture dialog capture toolbar
You must stop running before exit.	
Hardware configuration is not a 256 color palette.	
Hardware configuration has less than 8 MBytes of memory available.	
File does not exist.	File | Load
File name contains illegal characters.	File | Load File | Save As
Directory path does not exist.	File | Load File | Save As

Message	Generated By
Error in directory path or file name.	File | Load File | Save As
Start record (%ld) is beyond the end of the file (%ld).	File | Load
Start record plus number records (%ld) is beyond the end of the file (%ld).	File | Load
This is not a valid LBA-PC data file.	File | Load File | Save As
File's camera does not match configuration camera. Press OK to change the configuration camera.	File | Load
File's resolution (%d) does not match configuration resolution (%d). Press OK to change the resolution to '%d'.	File | Load
File's pixel scale (%.3le) does not match configuration pixel scale (%.3le). Do you want to change the pixel scale to %.3le?	File | Load
This is not a Demo frame.	File | Load File | Save As
File's camera does not match configuration camera.	File | Save As
File's resolution (%d) does not match configuration resolution (%d).	File | Save As
Cannot write to file created by previous version of LBA-PC.	File | Save As
Not enough memory for PassFail buffers. PassFail will be disabled.	results
Not enough memory for Computations buffers. Computations will be disabled.	results
Error Loading WING.DLL: %d	
LBA-PC device driver not found. LBA-PC set to Off-Line mode.	device driver
Frame Grabber not found. LBA-PC set to Off-Line mode.	device driver
Device Driver v%d.%d detected. LBA300-PC requires v%d.%d. 300-PC set to Off-Line mode.	device driver

Message	Generated By
%s detected but cannot be initialized. LBA-PC set to Off-Line mode.	device driver
Unable to load LCA program file (%s).	device driver
Press OK to stop Auto Calibration.	ultracal

A.5.4.6 FRM - upload/download a data frame

Only one frame at a time can be uploaded or downloaded. :FRM will upload a frame of data from the controller to the LBA-PC, while :FRM? will download a frame of data from the LBA-PC to the controller. Data is uploaded to or downloaded from the LBA-PC's frame buffer.

:FRM? <configuration> (LBA300PC → CONTROLLER)

Key	Type	Value Description
FrameNumber	I	frame number -1 = gain frame 0 = reference frame 1 to n. 'n' is the size of the frame buffer. default = current frame

Returns:

FRM FrameNumber=f;#dn..n(DAB)(DAB)…(DAB)(DAB)

Where:

f = frame number

= pound symbol

d = number of digits to follow in n..n

n..n = number of data bytes

(DAB) = data byte - 8-bit data byte

:FRM [FrameNumber=f;][Replace=B;]#dn..n(DAB)(DAB)…(DAB)(DAB)

:FRM <configuration> (CONTROLLER → LBA300PC)

(DAB)(DAB)…(DAB)(DAB) must be exactly what was returned by a previous :FRM? command.

Where:

f = frame number

= pound symbol

d = number of digits to follow in n..n

n..n = number of data bytes

(DAB) = data byte - 8-bit data byte

Key	Type	Value Description
FrameNumber	I	frame number -1 = gain frame 0 = reference frame 1 to n. 'n' is the size of the frame buffer. default = current frame
Replace	B	default = false true = replace If the camera or the camera resolution stored in the file do not match the current configuration then the LBA-PC must replace the current camera or change the resolution before the frame can be loaded. Either of these changes results in clearing the frame buffer (i.e. all current frames are discarded). If the pixel scale stored in the file does not match the current pixel scale then the pixel scale will be set to the value in the file. If the *energy* calibration stored in the file does not match the current *energy* calibration then the *energy* calibration will be set to the value in the file. false = do not replace If the camera or camera resolution do not match then the LBA-PC will issue an error and the frame is not loaded. The pixel scale and *energy* calibration values will not be changed.

A.5.4.7 FST - frame status information

:FST <configuration>[1,3]

:FST? [FrameNumber=f]

Returns:

FST <configuration>[2]

Key	Type	Value Description
FrameNumber	I	frame number -1 = gain frame 0 = reference frame 1 to n. 'n' is the size of the frame buffer. default = current frame
Date[4]	D	MM/DD/YY
Time[4]	T	HH:MM:SS.DD
CameraInput[4]	L	0 = camera 1 1 = camera 2 2 = camera 3 3 = camera 4
PixelBits[4]	I	number bits in raw pixel
PixelHScale[4]	F	horizontal pixel scale
PixelVScale[4]	F	vertical pixel scale
PixelUnits[4]	L	0 = none 1 = μm 2 = mm 3 = cm 4 = m 5 = in 6 = mils 7 = mrad
Gamma[4]	F	gamma correction performed on frame
Lens[4]	B	
PixelBitsFraction[4]	I	number of bits in fraction
CaptureLocation[4]	I,I	X,Y upper left corner of capture area (see also PAN)
CaptureSize[4]	I,I	frame width and height
CaptureResolution[4]	L	-1 = Full 1x 0 = 1x 1 = 2x 2 = 4x 3 = 8x 4 = 16x

Key	Type	Value Description
		5 = 32x
EnergyOfBeam[4]	F	calibrated energy of beam entered in Computations dialog
EnergyOfFrame[4]	F	raw frame total equivalent to EnergyOfBeam
EnergyUnits[4]	L	0 = j 1 = mj 2 = uj 3 = nj u = pj 5 = w 6 = mw 7 = uw 8 = nw 9 = pw 10 = fl
AC[4]	L	-1 = ultracal was on but capture location, frame size, or resolution did not match 0 = ultracal off >0 = ultracal subtracted
RS[4]	L	-1 = reference subtract was on but capture location, frame size, or resolution did not match 0 = reference sub off 1 = reference sub subtracted
GC[4]	L	-1 = gain correct was on but capture location, frame size, or resolution did not match 0 = gain correct off 1 = gain correct multiplied
CommentLine[3]	S	up to 256 characters
WriteProtect[3]	B	1 = cannot overwrite this frame

A.5.4.8 LOC - go to local

When the LOC message is sent or when the LBA-PC goes from remote to local via the REN line then local control is restored (equivalent to password lockout being disabled).

When in local control mode, any remote logging (:LOG) or synchronization (:SYC) is disabled, or cannot be enabled. The remote logging state is stored in the configuration. Remote logging is automatically re-enabled when the LBA-PC is returned to remote mode and the file name is FRM, RDD, or RDR.

:LOC

Returns:

LOC

A.5.4.9 ORG - set manual origin to cursor location

This command is valid only when origin is set to manual (see :DIS).

:ORG

A.5.4.10 PAL? - read color palette

This command retrieves the color palette currently used to display the beam on the LBA-PC. The LBA-PC uses a base palette of 128 colors to display pixels in the range of 0 to 255.

:PAL?

Returns:

PAL #3384(RDAB)(GDAB)(BDAB)…(RDAB)(GDAB)(BDAB)

Where:

= pound symbol

3 = number of digits to follow

384 = number of data bytes to follow

(RDAB)(GDAB)(BDAB) = 24 bit red, green, blue color value

A.5.4.11 PAN - pan left/right/up/down

:PAN <configuration>

Key	Type	Value Description
X	I	new upper left corner [+|-]x -x = move left by x x = new location - see :PNW? for limits +x = move right by x C = center horizontally
Y	I	new upper left corner [+|-]y. Note that the top is 0 and y values always increase going down.

Key	Type	Value Description
		-y = move up by y y = new location - see :PNW? for limits +y = move down by y C = center vertically

±x and ±y use units defined by the camera resolution in the current camera configuration. For example, if the camera resolution is x2 then ±x and ±y will move the capture window by ±2·x, ±2·y pixels. If the camera resolution is x8 then ±x and ±y will move the capture window by ±8·x, ±8·y pixels. Absolute locations will be snapped to integer multiples of the camera resolution.

:PAN?

Returns:

PAN <configuration>[2]

Key	Type	Value Description
CaptureLocation	I,I	X,Y - upper left corner of capture area
CaptureSize	I,I	X,Y - width and height of frame size
CaptureResolution	L	-1 = Full 1x 0 = 1x 1 = 2x 2 = 4x 3 = 8x 4 = 16x 5 = 32x

A.5.4.12 PNW - pan window limits

:PNW?

This command returns pan window limits. These are the dimensions of the active area of the camera detector and the allowable limits of the manual origin. These limits are defined in the Special Camera Settings dialog.

The current capture location and size must fit inside of the rectangle defined by the values returned from PNW?. The current capture location and size can be obtained with the :PAN? or :CAP? command. To determine the number of pixels actually covered by the capture area you must multiply the capture size by the capture resolution. For example, 128x120x4 actually covers 512x480 pixels, 64x60x2 actually covers 128x120 pixels, etc.

NOTE: The detector origin is always the upper left corner so that y values increase going down and decrease going up.

Returns:

PNW <configuration>[2]

Key	Type	Value Description
UpperLeft	I,I	X,Y - minimum allowable capture location
LowerRight	I,I	X,Y - maximum allowable capture location. Note that the capture location plus the capture size times the capture resolution must be less than these values.

A.5.4.13 PFS? - read pass/fail status

:PFS?

Returns:

PFS <configuration>

Note: Only results that are tested are returned.

Key	Type	Value Description
Label	S	Label string as displayed in the Results window.
Status	B	0 = fail, 1 = pass

Example return:

:PFS Total=1;Peak=0;Centroid X=0;Centroid Y=1;;

Total, Peak, Centroid X, and Centroid Y are being tested. Total passed, Peak failed, Centroid X failed, Centroid Y passed.

A.5.4.14 RCC? - read cursor column

:RCC? <configuration>

Key	Type	Value Description
FrameNumber	I	Frame number -1 = gain frame 0 = reference frame

Key	Type	Value Description
		1 to n. 'n' is the size of the frame buffer. default = current frame
Column	I	1 to w. 'w' is the frame width default = current cursor location

Returns:

RCC FrameNumber=f;Column=c;#dn..n(DAW)(DAW)…(DAW)(DAW)

Where:

f	=	frame number
c	=	which column is being returned
#	=	pound symbol
d	=	number of digits to follow in n..n
n..n	=	number of data words (i.e. column height)
(DAW)	=	data word is two 8-bit data bytes, low byte followed by high byte

Each data word is a two's complement fixed point value in one of the following formats:

siiiiiii ifffffff	LBA-300PC	-256 to 255.9921875
siiiiiii iiifffff	LBA-400PC	-1024 to 1023.96875
siiiiiii iiiiifff	LBA-500PC	-4096 to 4095.875
siiiiiii ifffffff	LBA-708PC	-256 to 255.9921875
siiiiiii iiifffff	LBA-710PC	-1024 to 1023.96875
siiiiiii iiiiifff	LBA-712PC	-4096 to 4095.875
siiiiiii iiiiiif	LBA-714PC	-16384 to 16383.5

Where:

s	=	sign bit
i	=	integer
f	=	fraction

Use the :FST? command to determine the specific fixed point format of pixels in a frame. The PixelBits parameter specifies the number of integer bits. The PixelBitsFraction parameter specifies the number of fraction bits.

A.5.4.15 RCR? - read cursor row

:RCR? <configuration>

Key	Type	Value Description
FrameNumber	I	Frame number -1 = gain frame 0 = reference frame 1 to n. 'n' is the size of the frame buffer. default = current frame
Row	I	1 to h. 'h' is the frame height. default = current cursor location

Returns:

RCR FrameNumber=f;Row=r;#dn..n(DAW)(DAW)…(DAW)(DAW)

Where:

f	=	frame number
r	=	which row is being returned
#	=	pound symbol
d	=	number of digits to follow in n..n
n..n	=	number of data words (i.e. row length)
(DAW)	=	data word is two 8-bit data bytes, low byte followed by high byte

Each data word is a two's complement fixed point value in one of the following formats:

siiiiiii ifffffff	LBA-300PC	-256 to 255.9921875
siiiiiii iiifffff	LBA-400PC	-1024 to 1023.96875
siiiiiii iiiiifff	LBA-500PC	-4096 to 4095.875
siiiiiii ifffffff	LBA-708PC	-256 to 255.9921875
siiiiiii iiifffff	LBA-710PC	-1024 to 1023.96875
siiiiiii iiiiifff	LBA-712PC	-4096 to 4095.875
siiiiiii iiiiiiif	LBA-714PC	-16384 to 16383.5

Where:

s	=	sign bit
I	=	integer
f	=	fraction

Use the :FST? command to determine the specific fixed point format of pixels in a frame. The PixelBits parameter specifies the number of integer bits. The PixelBitsFraction parameter specifies the number of fraction bits.

A.5.4.16 RDD? - read raw data

Returns the binary frame data.

:RDD? <configuration>

Key	Type	Value Description
FrameNumber	I	frame number -1 = gain frame 0 = reference frame 1 to n. 'n' is the size of the frame buffer. default = current frame

Returns:

RDD FrameNumber=f;Width=w;Height=h;#dn..n(DAW)(DAW)…(DAW)

Where:

f	=	frame number
w	=	number of columns
h	=	number of rows
#	=	pound symbol
d	=	number of digits to follow in n..n
n..n	=	number of data words
(DAW)	=	data word is two 8-bit data bytes, low byte followed by high byte

Each data word is a two's complement fixed point value in one of the following formats:

siiiiiii ifffffff	LBA-300PC	-256 to 255.9921875
siiiiiii iiiffffff	LBA-400PC	-1024 to 1023.96875
siiiiiii iiiiifff	LBA-500PC	-4096 to 4095.875
siiiiiii ifffffff	LBA-708PC	-256 to 255.9921875
siiiiiii iiiffffff	LBA-710PC	-1024 to 1023.96875
siiiiiii iiiiifff	LBA-712PC	-4096 to 4095.875
siiiiiii iiiiiiif	LBA-714PC	-16384 to 16383.5

Where:

s = sign bit

i = integer

f = fraction

Use the :FST? command to determine the specific fixed point format of pixels in a frame. The PixelBits parameter specifies the number of integer bits. The PixelBitsFraction parameter specifies the number of fraction bits.

A.5.4.17 RDR? - read results

:RDR? <configuration>

Key	Type	Value Description
Labels	B	Return labels displayed in left-hand column of results window. Default = false
Values	B	Return values displayed in center column of results window. Default = true
Units	B	Return units displayed in right-hand column of results window. Default = false

Returns:

each "set" is returned separately

RDR label,…,label

If statistics is enabled then returns:

RDR label,Mean,Deviation,Minimum,Maximum,…,

label,Mean,Deviation,Minimum, Maxmum

RDR value,…,value

If statistics is enabled then returns:

RDR value,mean,dev,min,max,…,value,mean,dev,min,max

RDR units,…,units

A.5.4.18 REM - go to remote

When the REM message is sent or when the LBA-PC goes from local to remote via the REN line then local control is automatically locked out (equivalent to password lockout).

Note that remote logging (:LOG) or synchronization (:SYC) are allowed only when remote is enabled. If remote logging was enabled in the configuration (i.e. file name was FRM, RDD, or RDR) and you set the LBA-PC to remote, then remote logging will be re-enabled. The synchronization state is not kept in the configuration so you must send a new SYC command after the LBA-PC is in remote.

:REM

Returns:

REM

A.5.4.19 RUN - start running

This command has no effect if the LBA-PC is already running.

:RUN

A.5.4.20 STP - stop running

This command has no effect if the LBA-PC is already stopped.

:STP

A.5.4.21 STT - start/stop toggle

Toggle start/stop equivalent to Start/Stop on main LBA-PC menu.

:STT

A.5.4.22 SYC - synchronize with remote

SYC forces the LBA-PC to wait until data, results, or both have been queried and sent before capturing another frame. This command is similar to :LOG with the file name set to FRM, RDD, or RDR, except the LBA-PC does not automatically send the response data.

:SYC <configuration>[3]

Key	Type	Value Description
Data	B	true = synchronize remote data download Do not capture another frame until the controller sends a :FRM? or :RDD? Command and reads the response data. false = normal operation

Key	Type	Value Description
		default = false
Results	B	true = synchronize remote results download Do not capture another frame until the controller sends a :RDR? command and reads the response data. false = normal operation default = false

A.5.4.23 WLD? - read current frame boundaries

This command returns the boundaries of the current frame as viewed in the beam window (i.e., this is the range of values that will be displayed in the status bar if you move the cursors in the beam window from the upper left corner to the lower right corner). The commands :APT, :CHR, :CUR require "world coordinates". World coordinates are dependent on the frame size, capture resolution, origin location, and pixel scale. This command returns the upper left and lower right corners of world coordinates of the current frame.

Note: If the origin is set to upper left window or upper left detector then y values increase going down and decrease going up.

:WLD?

Returns:

WLD <configuration>[2]

Key	Type	Value Description
UpperLeft	F,F	X,Y - upper left corner as viewed in beam window
LowerRight	F,F	X,Y - lower right corner as viewed in beam window

A.5.4.24 ZOM - zoom in/out

This command is identical to ":CAP ZoomIndex=z" and is provided for convenience. Allowable range is defined by ":CAP?" and "NumZooms=n".

:ZOM <configuration>[2]

Key	Type	Value Description
Zoom	L	new zoom [+|-]z -z = zoom out

Key	Type	Value Description
		z = new zoom +z = zoom in

:ZOM?

Returns:

ZOM Zoom=z

A.5.4.25 ZMM - zoom information

:ZMM?

Returns:

ZMM <index=zoom>;…;<index=zoom>;;

Where:

Index = zoom = list of zooms by index.

The "index" is an integer index used or returned by the ZOM command.

The "zoom" is of the form "W x H x R", W=width, H=height, R=resolution.

For example:

ZMM 0=128x120x4;1=128x120x2;2=128x120x1;3=64x60x1;4=32x30x1;;

A.6 Footnotes

[1]Commands to set a configuration have the following format:

:CCC key=value;key=value;…key=value;key=value;

Where:

:	=	ASCII colon character (0x3A)
CCC	=	three character command code (case is ignored) followed by space or tab
key	=	code for which parameter to set (case ignored)
=	=	ASCII equal sign (0x3D)
value	=	value to be assigned to the parameter specified by key.

The particular parameter type, format, and allowable range are dependent on which key is being set.

;	=	ASCII semi-colon character (0x3B)
key	=	value can occur in any order.

[2]Configuration query commands return all of the keys for the specified configuration in the following format:

:CCC key=value;key=value;…key=value;key=value;

[3]Cannot be set while LBA-PC is running.

[4]Cannot be set, information only.

[5]World coordinates are based on the frame size, capture resolution, origin location, and pixel scale. Use the WLD? command to determine frame current boundaries. World coordinate values will always be snapped to the nearest resolution pixel.

[6]The backslash character, "\", has special meaning known as an escape sequence. To specify a single backslash you must send two (2). *For example:*

"c:||spiricon||lba300pc||lbapc.cfg" is interpreted by the LBA-PC as, "c:|spiricon|lba300pc|lbapc.cfg".
Although other escape sequences are recognized there is no reason to ever use them with the LBA-PC.

Appendix B LabVIEW Support

B.1 Introduction

LabVIEW is a product and registered trademark of National Instruments Corporation. LabVIEW is a general purpose programming system designed specifically for data acquisition and instrument control. LabVIEW programs are called Virtual Instruments (VI's) because their appearance and operation can mimic other instruments such as the LBA-PC laser beam analyzer. Thus, your LBA-PC can be remotely controlled by Virtual Instruments created using National Instruments LabVIEW.

The User Guide describes remote operation of the LBA-PC.

B.1.1 Virtual Instrument (VI) Examples

To assist you with the development of specialized VI's for your application, Spiricon has supplied you with two libraries containing both basic and general VI examples. These examples are not provided as solutions to any specific requirement that the user might have in mind. Rather they are supplied to assist the VI designer in the development of their own specialized VI.

B.1.2 LBA-PC Remote Control Capabilities

Essentially all LBA-PC operations can be controlled remotely over a GPIB bus using National Instruments GPIB cards and LabVIEW developed VI's. Other sections of this manual detail the GPIB commands supported by the LBA-PC. It is assumed that the user is familiar with LabVIEW, and the meanings of the information provided below regarding the sample LabVIEW VI's. All of the following VI's require that the user has obtained a copy of the LabVIEW development software and has it installed on their PC. Spiricon has developed these VI's using LabVIEW for Windows version 6i, and makes no claims for their compatibility using earlier versions or other platforms. National Instruments GPIB interface hardware and their Windows drivers must be installed in both the remote (LBA-PC) computer and the local (or controlling) PC.

B.1.3 VI Libraries

If you checked the "Install Remote Capabilities" box during the installation of the LBA-PC application two VI library files, LBA-PC.LLB and SUBVI.LLB, will be installed in the following sub-directories:

C:\ SPIRICON

\ LBAPC

\LABVIEW GPIB Examples

LBAPC.LLB

SUBVI.LLB

You can either copy these library files to your LabVIEW development computer, or read these files from the Spiricon supplied CD.

B.2 The Basic SubVI Library Examples

SUBVI.LLB contains 22 basic functions that can be called by other VI's. The functions of these SubVI's are analogous to subroutines in other types of programming environments, such as C++ . The following list contains the library SubVI's name, a brief description of what it does, and the standard Inputs and Outputs of the VI.

B.2.1 Auto Aperture ON/OFF .vi

Description: Turn on/off auto aperturing.

Input	Output
1.GPIB address 2.On/Off Boolean 3.Error in	1.Error out

B.2.2 Comma String to Array .vi

Description: Translate a comma delimited string to an array.

Input	Output
1. Input string	1. The array 2. The total # of rows in the array

B.2.3 Display Beam Frame .vi

Description: Get current frame from LBA-PC, and display it as intensity graph.

Input	Output
1. GPIB address 2. Error in	1. Frame # 2. Beam frame 3. Width 4. Height

	5. Error out

B.2.4 Do Ultracal .vi

Description: Turn Ultra calibration on and wait to be completed.

Input	Output
1. GPIB address 2. Error in	1. Error out

B.2.5 Frame SRE .vi

Description: Enable Service Requests for frame data.

Input	Output
1. GPIB address 2. Error in	1. Error out

B.2.6 Get Basic Results .vi

Description: Get current results from LBA-PC .

Input	Output
1. GPIB address 2. Error in	1. Results array 2. Error out

B.2.7 Get Frame Status Info .vi

Description: Get current frame status information from LBA-PC .

Input	Output
1. GPIB address 2. Error in	1. Frame # 2. Horizontal Scale 3. Vertical Scale 4. Capture Resolution 5. Error out

B.2.8 Get Palette .vi

Description: Get color palette table from LBA-PC .

Input	Output
1. GPIB address 2. Error in	1. Color table 2. Error out

B.2.9 Get Pan Location .vi

Description: Get current pan location .

Input	Output
1. GPIB address 2. Error in	1. Left 2. Up 3. Width 4. Height 5. Capture resolution 6. Error out

B.2.10 Get Tophat Results .vi

Description: Get current tophat results from LBA-PC .

Input	Output
1. GPIB address 2. Error in	1. Tophat results array 2. Error out

B.2.11 Get Version .vi

Description: Get the version information of the LBA-PC.

Input	Output
1. GPIB address 2. Error in	1.Version information string 2. Error out

B.2.12 Move Cursor .vi

Description: Move cursor based on a click of one of four buttons.

Input	Output
1. GPIB address	1.Error out
2. Up button	
3. Left button	
4. Right button	
5. Bottom button	
6. Error in	

B.2.13 Move Pan .vi

Description: Move pan based on a click of one of four buttons.

Input	Output
1. GPIB address	1.Error out
2. Up button	
3. Left button	
4. Right button	
5. Down button	
6. Error in	

B.2.14 Read Basic Cursor info .vi

Description: Read cursor current location and it's value.

Input	Output
1. GPIB address	1. X-Location
2. Error in	2. Y-Location
	3. Pixel value on the cursor
	4. Delta from cross hair
	5. Error out

B.2.15 Read Cursor Column/Row .vi

Description: Read cursor row data and column data .

Input	Output
1. GPIB address 2. Error in	1. Row data array 2. Row # of elements 3. Column data array 4. Column # of elements 5. Error out

B.2.16 Read Divergence Results .vi

Description: Read peak and divergence x, y values in an array.

Input	Output
1. GPIB address 2. Error in	1. Value array 2. Error out

B.2.17 Restore Configuration .vi

Description: Restore a configuration file.

Input	Output
1. GPIB address 2. CFG file name string 3. Error in	1. Error out

B.2.18 Results SRE .vi

Description: Enable Service Requests for results.

Input	Output
1. GPIB address 2. Error in	1. Error out

B.2.19 Run Stop .vi

Description: Make LBA-PC run / stop .

Input	Output
1. GPIB address 2. Run/Stop boolean 3. Error in	1. Error out

B.2.20 Save Configuration .vi

Description: Save a configuration file to remote machine.

Input	Output
1. GPIB address 2. CFG file name string 3. Error in	1.Error out

B.2.21 Semicolon String to Array .vi

Description: Translate a string with semicolon delimiters to an array.

Input	Output
1. Input string	1. The array 2. The total # of rows in the array

B.2.22 Set Energy and Units .vi

Description: Set the quantity of energy and energy unit (set zero to re-init).

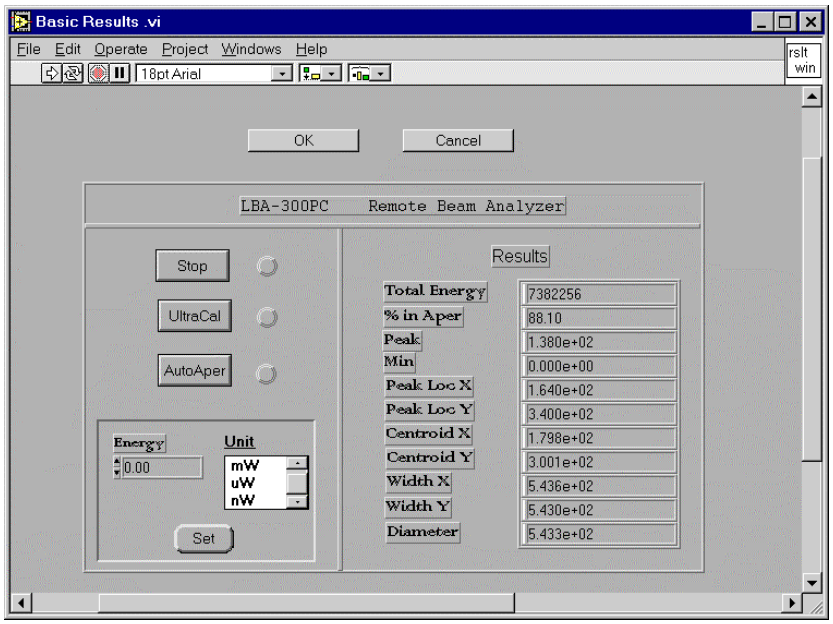
Input	Output
1. GPIB address 2. Energy 3. Unit 4. Error in	1. Error out

B.3 General VI Examples for the LBA-PC

The following examples demonstrate how to use the above SubVI's to build laser beam diagnostic LabVIEW virtual instrument applications. Two of these examples are described below in detail. The remaining are covered with a brief description of their operation. All of these examples are contained in the LBA-PC.LLB library file.

B.3.1 Basic Results .vi

This program shows the basic communication between LBA-PC and the local computer. It contains three buttons: "Run/Stop", "Ultracal", and "Auto Aper on/off" on the left side of the window. This VI shows all basic results on the right side.



Basic Results Panel

Figure 64

LabVIEW is a graphical computer language. In LabVIEW, user interfaces and displays are called "Panels" and a program is represented by a "Diagram". Programming is accomplished by drawing diagrams. A panel and its diagram are linked together.

In the Panel of "Basic Results .vi", there are five major groups of objects:

- Run/Stop button
- UltraCal button
- AutoCal button
- Energy spin control, Unit list, and Set button
- Results display array

For each group, we have built a SubVI to manipulate the process:

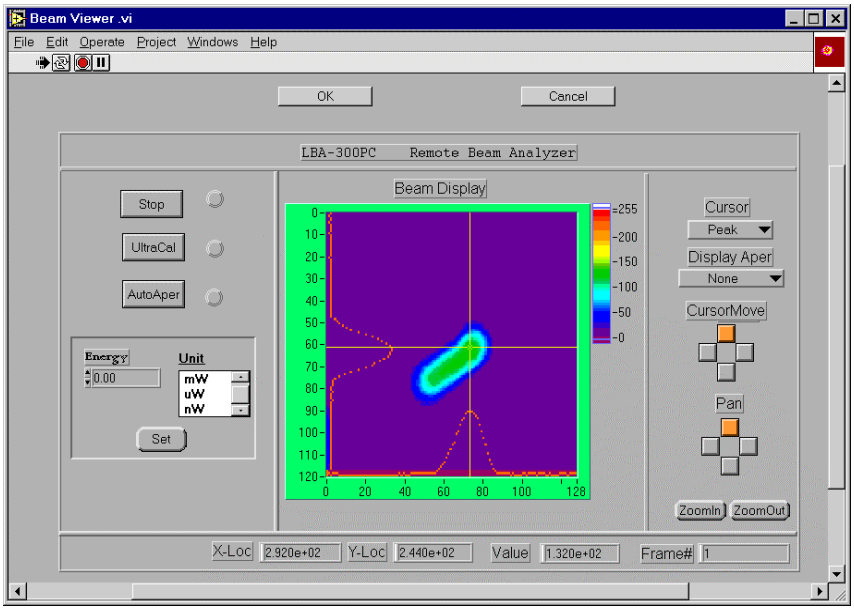
- Run Stop .vi
- Do Ultracal .vi
- Auto Aperture On/Off .vi
- Set Energy And Units .vi

- Get Basic Results .vi

These VIs are easy to understand if one has some experience in LabVIEW programming. The processing sequence is controlled by the "Error In" and "Error Out" connection chain. That means a function unit is processed earlier if it is closer to the starting "Error In" connection. In other words, we use the "Error Out" to "Error In" connection sequence to link each operation in the process. Since the results interface should be always active unless users terminate the process, we have used a "while-loop" to keep it active.

B.3.2 Beam Viewer .vi

This program allows you to control cursor and pan and zoom as well as basic operations. As in the previous example, Beam Viewer .vi utilizes some of the same SubVI's already discussed, while introducing image data transfers and a local display VI. However the design method is the same. We use SubVIs to manipulate each function, then link them together.



Beam Viewer Panel

Figure 65

In order to display intensity graphics, we used LabVIEW's "Attribute Note" feature to handle the size and palette, etc. Another LabVIEW tool we used to share data is "Local Variables". This allows you to use any variable value anywhere in a diagram.

Let us go through each major process step in the Beam Viewer .vi diagram. Before the while-loop, we enable frame Service Request and get Palette (if you want to change the palette, you should include get palette inside of this while-loop). Then:

1. Check if each of the Run/Stop, UltraCal, and AutoAperture buttons is on or off.
2. Check if Set energy/unit button has been clicked.

3. Check if the status of the cursor display has changed.

4. Check if any Cursor-Move button has been clicked.

5. Check if the ZoomIn and ZoomOut button has been clicked. Check if any Pan- Move button has been clicked.

6. Get current frame data and cursor location to display.

B.3.3 Basic Divergence .vi

This program is similar to the Basic Results .vi, but contains only those items needed to make divergence measurements. Inputs include the lens Focal Length and results items are: "Peak", "Div X" and "Div Y".

B.3.4 Basic Logging .vi

This program allows you to log data frames or results onto the remote (LBA-PC) computers hard disk. The operation of this VI is similar to the operation in the LBA-PC. The user inputs a filename and selects the logging method. Start/Stop and Closing of the logging process is also provided.

B.3.5 Basic Tophat .vi

This program is similar to the Basic Results .vi, but is configured to enable the LBA's Tophat results and display these results locally.

B.3.6 Load Data .vi

This VI will emulate the Load Data operation found on the LBA-PC. One or more LBA data frames can be retrieved from the LBA's local hard drive. The operator must enter a file name and path, the Start Record, the Number of Records, and the Start Frame values.

B.3.7 Save Data .vi

This VI will emulate the Save Data operation found on the LBA-PC. One or more LBA data frames can be saved on the LBA's local hard drive. The operator must enter the file name and path, and the Start Frame and Number of Frames values.

B.3.8 Put Data .vi

This VI will upload a data frame from the local computer's hard drive to the LBA-PC frame buffer. The operator must enter the file name and path, and the frame location number where the data is to be transferred.

B.3.9 Get Data .vi

This VI will download a data frame from the LBA-PC into a file on one of the local computer's hard drives. The operator must enter the file name and path, and the Frame Number that is to be transferred.

B.3.10 Hotkeys .vi

This VI provides a basic set of push-button operations including: Print, Write Protect, Reset, and Camera Shutter control. The "Reset" button will cause the LBA-PC application to restore the last saved configuration file.

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